SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1919.

GENERAL PHYSICS.

662. *Automatic Variation of Gas Pressure.* **O. Maass.** (Am. Chem. Soc., J. 41. pp. 53–59, Jan., 1919.)—Describes a device by means of which the pressure established by a Geissler, or any other suction pump, can be automatically varied between definite limits, and the period of each variation can be adjusted to any desired length of time. Such a control apparatus can be employed to make any Töpler mercury pump automatic, and in various other ways, which are described with the aid of diagrams. A. W.

663. *A Comparison of Anemometers under Open-air Conditions.* **A. N. Shaw.** (Roy. Soc. Canada, Trans. 12. pp. 131–134, Dec., 1918, and March, 1919. Monthly Weather Rev. 47. pp. 21–26, Jan., 1919.)—The paper contains a short abstract of some work on anemometer comparisons. The following methods of velocity determination were compared: (*a*) Robinson cup anemometer and pilot balloons over the first minute of ascent. (*b*) Robinson cup and simple Pitot tube anemometer. (*c*) Robinson cup and King's hot-wire anemometer. (*d*) Robinson cup and kata-thermometer, the latter used as an anemometer. (*e*) Hot-wire and kata-thermometer. J. S. Di.

664. *Use of a Simple Form of Pitot Tube under Open-air Conditions.* **A. N. Shaw.** (Roy. Soc. Canada, Trans. 12. pp. 135–138, Dec., 1918, and March, 1919.)—A simple type of Pitot tube combined with a graduated U-tube containing spirit is described. The readings were compared with those of a standard Robinson cup anemometer with satisfactory results. The probable error appeared to be less than 1 mile/hr. Average readings over half a minute were obtained (*a*) by estimating the average position of the spirit, and (*b*) by taking the average of the highest gust and lowest lull. The mean of (*a*) and (*b*) was considered to give a satisfactory mean value of velocity for the half-minute period. A table of fluctuations over half-minute intervals is set out. J. S. Di.

665. *System of Units.* **W. Dällenbach.** (Archiv f. Elektrot. 8. pp. 209–224, Jan. 26, 1919.)—Shows that by adopting a new system of units, the expression of a quantity can be caused to be the same in both the electro-

static and electromagnetic systems. The units adopted are: Length—cm.; Area—area of sphere of unit radius; Time—time required for light to travel unit of length in space. J. W. T. W.

666. *Elasticity of Metals as affected by Temperature.* **A. Mallock.** (Roy. Soc., Proc. 95. pp. 429–437, April 1, 1919.)—Fifteen metals are tested as to the variation of Young's modulus with temperature by using the metal as a spring carrying a load at its end. The vibrations were maintained by the mechanism of an electric clock. A theory is also advanced and is compared with the experimental results. E. H. B.

667. *Note on the Linguistic Nomenclature of Scientific Writers.* **A. Campbell.** (Phys. Soc., Proc. 31. pp. 80–81; Disc., 81–83, Feb. 15, 1919.)—Urges the avoidance of foreign plural forms. The term *pulsatance* is suggested as a suitable name for $2\pi n$, where n is the frequency. L. H. W.

668. *The Government and the Organisation of Scientific Research.* **F. Heath.** (Soc. Arts, J. 67. pp. 206–215; Disc., 215–219, Feb. 21, 1919. Chem. News, 118. pp. 127–129, March 14, and pp. 134–137, March 21, 1919.)—Gives an account of the work of the Department of Scientific and Industrial Research.

669. *Theory of Attraction when the Force Varies as any Power of the Distance.* **P. A. MacMahon** and **H. B. C. Darling.** (Roy. Soc., Proc. 95. pp. 390–399, April 1, 1919.)—Mathematical treatment unsuitable for abstraction.

670. *Temperature Coefficient of Tensile Strength of Water.* **S. Skinner** and **R. W. Burfitt.** (Phys. Soc., Proc. 31. pp. 131–136; Disc., 136, April, 15, 1919.)—The liquid is forced under pressure through a capillary constriction between two limbs of a U-tube. By trial the pressure is adjusted until the speed in the capillary is sufficient to produce rupture. This is judged by the sound and also the appearance. The whole U-tube is immersed in a bath, the temperature of which can be varied. Actual observations of rupture, velocity, and temperature, are recorded up to about 100° C., from which it is deduced that the tensile strength becomes zero in the neighbourhood of 245° C., which is in agreement with theory. AUTHORS.

671. *Notes on Lubrication.* **S. Skinner.** (Phys. Soc., Proc. 31. pp. 94–99; Disc., 99–100, April 15, 1919.)—Experiments on the pressure of air in the neighbourhood of a flywheel running in contact with a flat tangential board are described to exhibit the properties of a compressible lubricant. A comparison of the compressibilities and viscosities of the vegetable and mineral oils leads to the conclusion that the special property of "oiliness" is the physical property of incompressibility. In Note II. Worthington's experiments on the adhesion of two solids immersed in a stretched liquid are explained as an illustration of the phenomena of lubrication in a stretched liquid. In Note III. the effect of glass beads, etc., in promoting the free boiling of air-free water is explained by the occurrence of cavitation behind the moving beads, etc., the steam entering the cavities thus produced and dilating them into large bubbles. AUTHOR.

672. *Angle of Contact on Glass made by Mercury when covered with another Liquid.* **A. L. Clark.** (Roy. Soc. Canada, Trans. 12. pp. 51–53, June and

Sept., 1918.)—Measurements are given of the angle of contact of mercury and glass when various liquids cover the mercury surface. With glass-mercury and air, the angle measured in mercury varies between 142° 59′ and 147° 36′. For glass-mercury and water, the angle measured in water is between 4° 7′ and 5° 45′ with occasionally higher values probably due to traces of dirt. With glass-mercury and a strong solution of H_2SO_4 the value is always 0°, but somewhere between a 2 % concentration and pure water the angle passes from 0° to about 5°. The exact point of change is probably for a concentration of less than ½ %. For glass-mercury-water the condition is stable, but with the acid-mercury surface for all but the smallest concentrations, it is unstable. Experiment proves that the acid tends to creep between the mercury and the glass, strong solutions creeping more rapidly than weak ones. T. H.

673. *Measurement of the Thickness of Film formed on Glass and Sand.* **E. Pettijohn.** (Am. Chem. Soc., J. 41. pp. 477–486, April, 1919. Chem. News, 118. pp. 295–296, June 20, and pp. 306–309, June 27, 1919.)—The materials used consisted of purified ordinary river sand, Ottawa sand, and glass pearls. These were graded by meshing, and the sizes of the particles determined. The measurements were carried out as follows: 200 gm. of the air-dry sample was weighed and transferred to a clean, dry, conical flask, which was then closed by means of a stopper carrying a weight burette. The liquid was run in from the burette a drop at a time, the sand being thoroughly shaken after the addition of each drop. Towards the end of the titration only fractions of a drop were added. A final addition of liquid caused a large number of the grains to stick to the walls of the flask. The weight of the liquid thus used gave the amount of liquid taken up when a film of max. thickness formed. Using grains of different sizes, and the same liquid (water), the results obtained indicate that there are two factors which influence the amount of liquid necessary to form the max. thickness of film. The first factor is the amount of surface, the actual area that the film must cover. The second is the nature of the surface itself, its capacity to hold a film. Using different liquids, namely nitrobenzene, water, aniline, dimethylaniline, phenyliodide, toluol, turpentine, and pyridine, it was found that the thickness of the film is independent of the kind of liquid used. This proves that the surface tension of the liquid has no effect on the amount of liquid required for a titration, since the surface tensions of the above liquids vary very greatly. It also shows that there is no chemical action, in the ordinary sense of the term, when a film of water forms on glass. The conclusion to be drawn is that these films are not due to the formation of a chemical compound, but that they are held by the free energy of the solid. It is inferred that the same conclusion may be drawn for a film formed from the vapour phase.

The actual thickness of film found is of the same order as that found by earlier investigators who worked with the vapour phase of water in forming the film. With water the values vary from 0·0000066 to 0·0000285 cm., although the majority of the results are round about 0·000018 cm. T. S. P.

674. *Determination of Surface Tension (Free Surface Energy) and the Weight of Falling Drops: Surface Tension of Water and Benzene by the Capillary Height Method.* **W. D. Harkins** and **F. E. Brown.** (Am. Chem. Soc., J. 41. pp. 499–524, April, 1919.)—A discussion is first given of the two methods most commonly used for determining surface tension—namely, the capillary rise method and the drop-weight method. The theory of the former is simple but its technique is difficult, and its use in some cases is the cause of errors as high as 30 %, due to its inapplicability to certain classes of substances. The drop-weight method is applicable to a wide range of liquids and the experimental work is not difficult, but the theory of this method has not been fully worked out; as a consequence, many of the results obtained, although experimentally accurate, are not trustworthy on account of the use of an insufficient theory. In the present paper the relation between the experimental results of the drop-weight method and those obtained by the capillary rise method has been determined by using water and benzene, which are liquids that give accurate results by either method. This relation has been plotted in such a way as to show the relation between surface tension and the form of a drop which falls from a circular tip. Using the capillary rise method the surface tension and capillary constant of water and benzene at 20°, each against air saturated with its own vapour, were found to be $\gamma = 72{\cdot}800$ dynes/cm.; $a^2 = 14{\cdot}897$ mm.^{2} for water, and $\gamma = 28{\cdot}80$ dynes/cm.; $a^2 = 6{\cdot}713$ mm.^{2} for benzene. The importance of steaming out the tubes with the vapour of the substance under investigation is emphasised. For example, the value of γ for water is increased by about 0·1 dyne by steaming out. Water, benzene, carbon tetrachloride, and ethylene dibromide were dropped from a large number of tips of glass and of metal with radii varying from 0·09946 cm. to 1·0028 cm., and the weights of the falling drops determined. From these data r/a and the corresponding values of $f(r/a)$ for the Lohnstein equation $Mg = 2\pi r\gamma f(r/a)$ were calculated for values of (r/a) between 0·25 and 2·60. The value of $f(r/a)$ is not constant, but varies from 0·7256 to 0·5352 in this range, whilst when r/a falls to 0·025 $f(r/a)$ rises to 0·924. It is assumed that in conjunction with other necessary conditions r/a really determines the shape of a hanging drop and that it is the shape of the drop which determines the fraction of the drop that falls. This shape may also be determined by the ratio of r to the cube root of the volume of the falling drop. Thus a new equation, similar to that of Lohnstein, is derived, $Mg = 2\pi r\gamma\psi(r/V)^{1/3}$. This is more easily applied to the determination of surface tension than Lohnstein's equation since all the factors except γ are obtained by direct experiment or by reference to a table of values, whilst the a of Lohnstein's equation cannot be determined from the direct results of the drop-weight measurements, but must be calculated by methods of approximation. Graphs of results and tables to be used in the calculation of γ by the drop-weight method are given. It was found that variations in density over a wide range and in viscosity over a moderate range, did not appreciably affect the results obtained for the surface tension of liquids by the drop-weight method. The weight of a drop varies rapidly with its time of detachment. In general the natural period of fall of a drop should be 5 minutes or more, if the weight is to be used for the determination of surface tension. If dilute solutions of long-chain organic molecules are used, it is often necessary to let the drop hang at almost full size for half an hour or more in order to obtain the static surface tension of the solution. Rayleigh's results show that open thin-walled tubes when used as tips do not give such accurate results as heavy-walled capillary tips or perforated discs. The results obtained in this investigation increase the accuracy of the drop-weight method by about 4 %, so that now its precision is approximately of the order of one-tenth of 1 per cent. when used within the limits and under the conditions given in this paper. It is often assumed, since several experiments on the same liquid by the drop-weight method may be made to agree within a few hundredths of 1 per cent., that this is an indication that the results calculated from the work give the surface tension with the same accuracy, in spite of the fact that nearly all such data given in the literature are 3 % or more too low. A source of error which is important in all drop-weight work, and which is a source of even more discrepancy in results obtained by methods involving the pressure volume, or buoyancy of a bubble of gas in the liquid, is that due to a lack of sharpness, or to the departure from the circular shape of the tip. Such errors become more important as the tip decreases in radius. Details are given of the methods used for the construction of satisfactory tips, and of the conditions which they should satisfy. Possibly the most common error in the use of the drop-weight method is that expressed in a large number of papers in statements which involve the assumption that while a comparison of the weights of the drops, or of the drop number, obtained in different experiments may not give the correct absolute value of the surface tension, its use in that particular paper is justified since "only the relative values are desired." Except in certain special cases, this is just what such comparisons of the drop-weights do not give, and the error introduced in this way is often as high as 10–15 % in work at the interface between two liquids ; it may rise as high as 10 % at the liquid-vapour interface when solutions of organic substances are used, but is usually considerably less than this when the surface tension of a pure liquid is measured. The drop-weight correction curves found by the authors have a form represented by a cubic equation ; the right-hand branch of the curve has thus an entirely different form from that found by Lohnstein. This is considered to be one of the most important results obtained.

The data given indicate that in the determination of the surface tension of a single liquid, only the difference in density between the two fluids, liquid and vapour, and not the ratio of the two, appears. The relations might well be different at the interface between two liquids, where the density of the lighter phase becomes relatively more important. It is also pointed out that the authors' factors of correction are also involved when the surface tension is measured by the method of bubbling air upward through a liquid.

T. S. P.

675. *Theoretical Significance of Viscosity Measurements of Colloidal Solutions.* **S. Arrhenius.** (Nobel Inst., Meddel. 3. No. 4. (21) pp. 1–22, 1918.)—A general discussion of the subject in which it is pointed out that the formula of Einstein respecting the viscosity of dilute solutions is completely upheld by the experiments of Bancelin in the region where the logarithmic formula applies. Einstein's formula agrees very well also with the measurements of Mifka on suspensions of silver, gold, and copper. The extension by v. Smoluchowski of Einstein's formula gives no concordant result according to the determination by Oden of the viscosity of colloidal sulphur solution.

E. H. B.

676. *Theory of the Friction of Liquids.* **J. D. van der Waals, Jr.** (K. Akad. Amsterdam, Proc. 21. 5. pp. 743–755, 1919.)—In the introduction to this paper it is pointed out that while the theory of the friction of gases has been made the subject of numerous researches, that of liquids has, on the other hand, received scant attention. Yet it is clear that the explanation given to account for the friction of gases—namely, that it is brought about in consequence of molecules diffusing from one gas layer to another and thereby transporting an amount of momentum from one layer to another—cannot equally apply to the friction of liquids. Since the friction of gases increases with temperature, while with liquids the viscosity falls, such

behaviour cannot be accounted for as "friction by means of transport." It is now shown that an explanation of the friction is afforded from the forces which the molecules exert on each other. If at an arbitrary moment the motion of the molecules could be suddenly checked, the friction by means of transport would be simultaneously destroyed; but with molecular forces, independent of the velocity, the frictional forces would continue to exist after the immobilisation of the molecules. They would be a consequence of the grouping of the molecules in space, so that the solution of the problem is to find the nature of the molecular forces and that grouping which gives rise to the existence of the tensor of tension as met with in the friction of liquids.

The following three solutions are discussed: (*a*) Friction through impact forces or through an instantaneous transfer of momentum. (*b*) Friction for double points. Formation of streaks. (*c*) Friction in consequence of formation of groups. Section 2 deals at some length with friction as a result of impact forces; and section 3 with testing the formulæ obtained for liquids not too near the critical point, a table of results being included. On the whole the agreement is as satisfactory as could be expected in view of the many approximations. Generally the experimental value is somewhat smaller than the theoretical one; for ether more than for other substances, benzene and *ortho*-xylene deviating in the opposite sense. For acetic acid and for the alcohols the agreement is much less than for the normal substances. Later sections will deal with the amount of friction to be ascribed to the formation of groups. H. H. Ho.

677. *Operational Methods in Physics.* **T. J. I'A. Bromwich.** (Phil: Mag. 37. pp. 407–419, April, 1919.)—The author states a formula, which is an extension of one due to Heaviside, as follows:—Suppose we have found, by operational methods, the symbolic equation $x = F(p)/\Delta(p)\,.\,(Gt)$, where G is a constant, and $p \equiv \partial/\partial t$, then this solution is to be interpreted as $x = G\left\{N_0 t + N_1 + \sum^{a} F(a)/a^2\Delta'(a).e^{at}\right\}$, where $p = a$ is any root of $\Delta(p) = 0$, the summation extends to all such roots, and N_0, N_1 are defined by $F(p)/\Delta(p) = N_0 + N_1 p + N_2 p^2 + \dots$ This solution has the property of reducing to zero at $t = 0$. Heaviside's formula

$$F(p)/\Delta(p)\,.\,P = P\left\{N_0 + \sum^{a} F(a)/a\Delta'(a)\,.\,e^{at}\right\}$$

[Electrical Papers, 2. pp. 226 and 378] can be derived from it by differentiation with respect to t. The author gives a simple proof of Heaviside's formula when $F(p)$, and $\Delta(p)$ are simple polynomials, and the latter is of the higher degree, and derives his own formula from it by integration and substitution subject to the condition that the solution vanishes for $t = 0$.

The method is applied to obtain solutions of some induction-balance problems and some heat problems of interest in connection with aeroplane thermometric observations, on the assumption that the temperature of the surrounding atmosphere is proportional to t, representing the assumption of a uniform rate of descent and a uniform temperature-gradient in the atmosphere. In obtaining the latter the formula has been used with more general types of functions than those for which it has been formally proved, as it appears natural to expect it still to remain valid. G. W. de T.

678. *Bernoulli's Equation.* **E. Cotton.** (Comptes Rendus, 168. pp. 547–549, March 17, 1919.)—Bernoulli's equation is considered for a perfect fluid under motion hydraulically steady and in a tube of finite section. Motion is defined as hydraulically steady when the pressure and velocity, con-

sidered as functions of the time, have oscillation, whose max. amplitudes are so feeble that their results may be neglected. Bernoulli's equation is shown to be applicable if the mean values, over a sufficiently long time, of the velocity, pressure, and external forces are employed. W. A. R.

679. *Contraction of Fluid Filament.* **L. Lecornu.** (Comptes Rendus, 168. pp. 481–484, March 10, 1919.)—Hugoniot's statement, that the contraction of a filament of a fluid in steady motion reaches a maximum when the velocity is that of sound under the conditions of pressure and density, is shown to be inexact. It is only in the smallest of contracted sections that the velocity of sound can be reached. W. A. R.

680. *Total Movement and Average Speed of Gas-flow from a Reservoir Emptied by a Pipe.* **A. Rateau.** (Comptes Rendus, 168. pp. 581–587, March 24, 1919.)—In a previous communication [Abs. 519 (1919)] the author has shown how to calculate, by taking the co-volume into consideration, the successive states of a gas at high pressure in the interior of a receiver which is emptied by a pipe into an infinite volume, such as the atmosphere. The present paper is limited to the calculation of the total amount of flow, and the average speed of the gas-jet from start to finish. This problem is presented in several technical operations, *e.g.* in gun recoil. It may be considered from different standpoints intermediate between the following two extreme cases: (1) The pipe being constructed in such a manner that it does not permit the complete outflow of the gas at the pressure of the surroundings (as by a solely converging pipe), the amount of total flow at the jet must be found corresponding exactly to the speed of the gas in the last section of this pipe. (2) The pipe may be assumed to adapt itself automatically to the instantaneous conditions of flow in such a way that the complete outflow of the gas might be brought about, and the total movement corresponding to this complete outflow must be calculated. The present author proceeds rather from the second standpoint, but has been compelled to neglect the co-volume owing to the extreme complexity of his formulæ rendering them unsuitable for numerical calculations. The modified formulæ are, however, well within the sphere of practical application because of the average and initial speeds of the gas being almost equal, so that the error introduced by omission of the co-volume is relatively very small.

The paper is entirely mathematical. H. H. Ho.

681. *Resultant of a Number of Unit Vibrations, whose Phases are at Random, over a Range not Limited to an Integral Number of Periods.* **Rayleigh.** (Phil. Mag. 37. pp. 498–515, May, 1919.)—The subject is treated by the theory of probability and the results are exhibited in six double-diagrams occupying a whole page. They are not, however, presented in a compact symbolic form that lends itself to intelligible abstraction. The original should be consulted. E. H. B.

682. *Configurations of Compressible Rotating Masses.* **J. H. Jeans.** (Roy. Soc., Phil. Trans. 218. pp. 157–210, April 2, 1919. Bakerian Lecture, 1917.)—The result announced in a previous paper [Abs. 413 (1914)], that the incompressible mass provides a good model for study of the behaviour of compressible masses is here, on the whole, confirmed. But a detailed study of a compressible mass is possible when the relation between pressure and density is expressible in the form $p = x\rho^{\gamma}$ — constant, where x and γ are constants, which includes the important case of a gas in convective equilibrium. The three equations of relative equilibrium for any mass rotating with angular velocity ω about the z axis are of the type $\partial p/\partial x = \rho \partial \Omega/\partial x$, where $\Omega = V + \frac{1}{2}\omega^2(x^2 + y^2)$, V being the total gravitational potential, including that of tidal forces from neighbouring stars if present. From detailed investigation given in earlier papers [Abs. 1840 (1917) and 364 (1917)], the author draws the conclusions that for practical purposes, the interior arrangement of the matter may be regarded as uniquely determined when the mass and external boundary, together with ω and the tide-generating masses, are given. Hence all the internal vibrations are necessarily stable, since instability can occur only through a zero-frequency vibration, involving two contiguous equilibrium arrangements of inferior matter. For a mass at rest under no tidal forces, the boundary and surfaces of constant density will be concentric spheres, becoming concentric spheroids, with slow rotation, ceasing to be strictly spheroidal, with increasing rotation; but there must always be a linear series of equilibrium configurations in which the boundary is a figure of revolution, which series reduces to Maclaurin spheroids, for incompressible matter. As shown in the paper last referred to, there will be an infinite number of points of bifurcation, provided the boundary density does not vanish, and this case is shown, in the present paper, not to present a true exception to the general theory, as was then mistakenly supposed. The first bifurcation point corresponds to the second sectorial harmonic, the circular section becoming slightly elliptic, leading to a series of figures with three planes of symmetry and three unequal axes, reducing to the Jacobean ellipsoids, for homogeneous incompressible matter. The author calls the two series pseudo-spheroids and pseudo-ellipsoids respectively. The first bifurcation point on the latter series corresponds to a third harmonic displacement, and leads to a pear-shaped series. It seems almost certain, though not strictly demonstrated, that this series ends by fission into two detached masses revolving round each other as in the ordinary binary star. Assuming this, the passing of the first bifurcation point on the pseudo-ellipsoids may be considered the beginning of fission. If then the pear-shaped figures are unstable for compressible, as they are for incompressible masses, pseudo-spheroids and pseudo-ellipsoids will be the only possible figures of stable equilibrium for compressible masses. In incompressible masses, the resultant normal force,$-\partial\Omega/\partial n$, at a point on the surface vanishes in the unstable configurations at the far ends of the spheroidal and ellipsoidal series, but in compressible matter it is found that it may vanish, either on the pseudo-spherical or pseudo-ellipsoidal series, and matter is then ejected at the vanishing points and the series abruptly terminated. Let $\epsilon = (\rho_0 - \sigma)/\rho_0$, where ρ and σ are the densities at the centre and the boundary. Then the method of studying the series of configurations is to take the known solution when $\epsilon = 0$, the case of an incompressible mass, as generating solution, and to obtain, by successive approximations, an expansion for Ω in the powers of ϵ. The solution of the problem of obtaining the potential of a homogeneous mass, expanded in powers of a parameter measuring its divergence from an ellipsoid, given in a previous paper [Abs. 95 (1917)] is extended to obtain the potential of a non-homogeneous distorted ellipsoid, and the equilibrium configurations are then studied in detail for the pressure-density law $p = x\rho^{\gamma}$ — constant. Compressibility is then found to postpone instability of the spheroidal form, and for $\gamma < 2$ there is no ellipsoidal bifurcation. It is found that for every mass which has been broken up by fission $\omega^2/2\pi\bar{\rho}$, where $\bar{\rho}$ is the average value of ρ, must at some time have exceeded the value 0·18712, which provides the keystone, so far wanting, to the author's argument [Abs. 864 (1917)], showing the improbability of the solar system having broken up by rotation alone. The outer strata are in general more lens-shaped than the inner when the latter are spheroidal, and more spindle-shaped when ellipsoidal. A sharp edge or sharp ends, respectively, may thus be developed from which matter may be ejected. If the bifurcation point occurs before a sharp edge in the pseudo-spheroidal stage, the innermost strata will become ellipsoidal, and the outer strata and boundary pseudo-ellipsoidal, and the mass will proceed towards the pear-shaped form and ultimate fission, otherwise the mass will disintegrate from equatorial loss of matter. For $\gamma < 1{\cdot}2$ the matter extends to infinity and the mass is infinite, and for $\gamma > 1{\cdot}2$ the extension and mass are finite. For $\gamma = 1{\cdot}2$ the extension is infinite and the mass finite, and equatorial loss of matter will occur with even the least rotation. For a critical value of γ determined by the equation

$$1 + \epsilon[(\gamma - 2) - 1{\cdot}0509] + \epsilon^2[\tfrac{1}{2}(\gamma - 2)^2 - 0{\cdot}4063(\gamma - 2) - 0{\cdot}0510] + \ldots = 0,$$

the crossover occurs from equatorial break-up to fission through pseudo-ellipsoidal and pear-shaped figures. For $\epsilon = 1$, that is, for a gas in which the density vanishes at the boundary, the terms written down give 2·5121, but the remaining terms seem likely to increase this somewhat, and the author estimates the value as approximately 2·2. When the boundary density is not zero, γ becomes less, *e.g.* for $\epsilon = 0{\cdot}75$, $\gamma = 1$. While the failure of a homogeneous mass to attain the ellipsoidal form is permanent, that of a heterogeneous mass of density increasing towards the centre may be merely transitory, the value of γ increasing with the ejection of matter, so that it may come to exceed the critical value. It appears that in the case of a star of small mass, say a tenth of the sun's mass, in which there is little atomic disintegration and the effect of radiation-pressure is negligible, it will not begin to break up into a binary star until it reaches a density of from ¼ to ½ that of water. But in more massive stars there will be considerable atomic disintegration owing to the very high internal temperatures, whether or no the radiation-pressure be comparable with the gas pressure, and this will lead to fission at lower densities, so that stars of greatest mass will begin the processes of fission in the earliest stages of their careers. The only stars whose masses are known are binaries bright enough to be observed, and it follows from the conclusions of the paper that the order of magnitude of their mass must exceed 10^{31} gm., so that the mass of such a star as W Crucis, assuming its two components to have been formed by the fission of a single body, must be very great indeed.

G. W. DE T.

683. *Energy Equations of the General Theory of Relativity.* **R. J. Humm.** (Ann. d. Physik, 58. 5. pp. 474–486, April 4, 1919.)—In an earlier investigation [Abs. 122 (1919)] the author was led to the assumption that the Einstein energy equations are to be regarded as equations of motion. The ratification of this assumption was obtained by starting from the simple relations of ordinary mechanics and seeking the formulation and interpretation of the energy hypothesis. This led to the general relativity problem. Apart from the number of independent variables, complete analogy rules between both problems. The present paper contains an attempt to generalise the energy hypothesis of mechanics with respect to a regulating time principle. It is found that the difference between the mechanical problem and that of general relativity lies only in the conditions for virtual displacement. Although from the properties of general invariance the parameters of the gravitational field are established and a clear interpretation denoted by them, yet there are no similar characteristics for the electrical parameters. The present paper now provides an expression from which a very intimate connection between material world-lines and the electromagnetic field may be deduced, since it cannot be destroyed by displacement. It is interesting to note that when the historical course is pursued, namely, Mechanics—Electrodynamics—Gravitation, difficulties are encountered in the elucidation of gravitational energy which are experimental, while, when starting from principles, and in the above order reversed, the correct gravitational energy is obtained, but difficulties with respect to principles arise in connection with electromagnetic energy. H. H. Ho.

684. *Dynamics of Spacial Atomic Structure.* **A. Landé.** (Deutsch. Phys. Gesell., Verh. 21. pp. 2–12, Jan. 30, 1919.)—A large series of facts are now in existence which support a spacial structure for the atom instead of the former conception of a flat ring system; for instance, the tetrahedral carbon atom which is necessary for understanding the majority of chemical processes in organic substances; also the cubic arrangement of 8 electrons. In the latter connection appears the formation of crystals, in which a tendency towards a definite crystalline structure must exist from the outset in the component atoms, since a space-lattice made up of rings is unstable. Further, the correct compressibility of regular crystals can only be explained on the cubic electronic arrangement, and never by an electronic ring system. The author has now succeeded in accomplishing the explanation of the polyhedral structure by means of simple hypotheses. Section 1 deals with orbit curves possessing polyhedral symmetry. Sections 2 and 3 investigate the tetrahedron and cube respectively. Section 4 examines the variety of periodic orbits. It is found that while the compressibility of regular crystals, among other facts, requires a cubic structure of the ions, a dynamic possibility of coupled electronic orbits occurs, whose combination possesses cubic (or tetrahedral) symmetry, and is a species of polyhedric union of electronic orbits in spacial analogy with Sommerfeld's union of plane ellipses. H. H. Ho.

685. *A Cloud Phenomenon.* **C. J. P. Cave.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 25–27; Disc., 27–28, Jan., 1919.)—On April 15, 1915, the front edge of an extensive cloud sheet passed south-eastwards across the south-east of England. There was a sharp line between the blue sky in front and the cloud sheet behind. Isochronous lines showing the time of cessation of sunshine over the district indicated the forward march of the cloud front. A diagram shows such lines which ran SW.–NE. across the country and advanced at the rate of about 5 metres/sec. A pilot-balloon ascent made at South Farnborough as the cloud sheet was approaching showed that the wind above the ½-km. level blew from about NW. and its velocity was approximately equal to the rate of advance of the cloud front. The height of the cloud sheet which was of st.-cu. type was not determined. J. S. Di.

686. *A Thermo-chemical Application of the Lattice Theory.* **M. Born.** (Deutsch. Phys. Gesell. Verh. 21. pp. 13–24, Jan. 30, 1919.)—From the calculation of the compressibilities of 10 regular crystals, proof has been forthcoming that the cohesion forces of these substances are of purely electrical origin, and the question arises as to whether this result admits of generalisa-

tion. Data for the solution should be afforded by chemical processes, *e.g.*, in the formation or decomposition of crystals where the electrical energy of the lattice may be made thermally manifest. An experimental difficulty here arises in that the measurable thermal effects in chemical operations constitute only a small fraction of the total transposed energy, since heat evolution is only the residue of the positive and negative effects which accompany disruption, ionisation, and orientation of the particles. While no sharp decisions may be expected, yet the author has thought it important to ascertain whether the calculated energy is in agreement with the observed thermal effects. Section 1 considers the potential energy of the lattice; section 2 gives the calculation of thermal effects from the lattice energy; section 3 investigates the relationship between lattice energy, thermal effect, and ionisation tension. Tables of results are given, and the general conclusion is drawn that the data obtained afford general support to the theory.

H. H. Ho.

687. *The Annual Symmetrical Variation of Certain Elements and a Note on the Choice of Seasons.* **E. H. Chapman.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 43–48; Disc., 48–51, Jan., 1919.)—Certain meteorological elements are plotted in a special manner in order to bring out their symmetry about different times of year. By this means it is shown that for the Midland Counties monthly temperature is most nearly symmetrical about Feb. 1 and Aug. 1. On the other hand, evaporation at Camden Square is almost perfectly symmetrical about Jan. 1 and July 1. It is found that the most appropriate division of the year into seasons differs for the different elements. The final conclusion reached is that the simplest and best seasons would be Winter—Middle of Dec. to Middle of March and so on, each season to consist of three calendar months. A diagram showing the annual variation of temperature in the upper air indicates that the coldest and warmest periods have a lag of about one month from 2–9 km. height behind the times for the surface but at still greater heights the seasons show a pronounced advance. Thus the coldest three months at 9 km. are Jan., Feb., and March, but at 14 km. Nov., Dec., and Jan. In the *discussion*, it was pointed out that this effect might be expected if the heating and cooling were effected at the top and propagated downwards. With regard to the earlier part of the paper, it was also pointed out that the words summer and winter have a definite meaning outside the limits of meteorology, and if it is desired to alter the meteorological seasons new names should be found to indicate the new periods.

J. S. Di.

688. *Lunar Tide in the Earth's Atmosphere.* **S. Chapman.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 113–137; Disc., 137–139, April, 1919.)—The aerial ocean is sufficiently uniform over the earth to suggest that a lunar atmospheric tide would be of simple character. According to elementary tidal theory the amplitude in pressure should be independent of longitude and diminish regularly with latitude: the phase should be everywhere constant, max. pressure occurring somewhat later than lunar transit: the period should be purely semi-diurnal, except possibly for a diurnal component varying in amplitude as the sine of twice the moon's declination, and therefore suffering reversal as the moon crosses the equator: the amplitude of the semi-diurnal term should vary as the square of the cosine of the lunar declination and as the inverse cube of the moon's distance: the tide should be independent of the position of the sun, *i.e.* of lunar phase and of season.

The present work was undertaken with a view to determining how far these conditions were realised in practice. The main facts deduced from the inquiry are as follows. The lunar daily barometric variation is purely semi-diurnal, even when the moon is 20° away from the equator. The data are inconclusive as regards the influence of lunar distance: there seems to be no change of phase angle, while though the amplitude is probably larger at perigree than at apogee the exact ratio has not yet been determined. The variation of amplitude with the moon's declination, which tidal theory predicts, is not detectable in the present results. A marked seasonal variation affecting both amplitude and, particularly, phase is one of the most surprising features of the phenomenon. As regards latitude, the amplitude diminishes rapidly from the equator, approximately as the fourth power of the cosine of the latitude; the phase angle which shows a retardation in the tropics seems to increase with latitude till it becomes in advance of the moon. There are indications of local irregularities both in amplitude and phase angle.

The paper gives an historical review of previous work on the subject, and a detailed account of the method of computation adopted in the present case. The data employed for the main part of the work consisted of 80 years' observations at Batavia (6° S.) and 28 years at Hongkong (22° N.). Use is also made of the results obtained from a long series of observations at Greenwich, which have been discussed previously by the present author, and of shorter period series for several stations discussed by other workers. The seasonal variations in amplitude and phase angle are found to be remarkably similar at Batavia and Hongkong. The Greenwich changes, though on a smaller scale, also show points of pronounced similarity. It is pointed out that the amplitude of the lunar atmospheric tide at the equator is 2·8 times as great as that predicted by the equilibrium theory. If the atmosphere has, as is probable, a free period of oscillation of semi-diurnal type and of slightly less than 12 hours' period, the magnifying effect of resonance seems quite sufficient to account for this or even a larger ratio. It is suggested that the atmospheric tide is also affected by the rise and fall of the oceanic tide and by other disturbing factors. Many minor points which cannot well be touched upon in an abstract are discussed in the paper. J. S. Di.

689. *Locating Submarine Faults.* **O. Klotz.** (Roy. Soc. Canada, Trans. 12. pp. 37–41, June–Sept., 1918.)—By utilisating data of the times, etc., of the three types of earthquake wave obtained from differentlysituated observatories, and plotting sterographically, it was found possible to locate a fault 300 km. long in the Kurile deep. This is the first mapping of a submarine fault, and further results should prove useful for determining the routes of submarine cables. W. A. R.

690. *Earthquake Waves and the Interior of the Earth.* **C. G. Knott.** (Engineering, 107. pp. 266–267, Feb. 28, 1919.)—Discourse delivered at the Roy. Inst., Feb., 1919.

691. *Application of Photoelectric Photometry to Astronomy.* **A. F.** and **F. A. Lindemann.** (Roy. Astron. Soc., M.N. 79. pp. 343–357, March, 1919.)—Relying on the principle that metal surfaces emit electrons under the influence of light so that the effect of different sources of light can be compared with a standard, the authors claim a special advantage for the method in the case of diffused objects like comets and nebulæ, as the total

light and not the intensity is indicated. The effect on alkali metals is selective, the maximum being at about 4400 Å. for K, 4800 for Rb, and probably 5500 for Cs. The energy received being very small, highly sensitive methods are required, one of which is to increase the original photoelectric current by surrounding the sensitive metal with a neutral gas and applying a negative potential to the metal, thus enabling each electron to form new ions by collision. Details are given of the apparatus and the method of adjustment of the photoelectric cell and of the electrometer made necessary by the smallness of the current obtained from even the brightest stars; also of the method of taking an observation. Unfavourable weather has prevented much actual work being done, but the authors indicate various directions in which the method should prove useful. (1) Stellar magnitude, not exactly visual nor photographic. (2) Stellar temperature, a sort of colour index being obtained by using alternately a potassium cell and a cæsium cell. (3) Star-counts. (4) Luminosity and temperature of nebulæ. (5) Photometry of comets and determination of their mass. (6) Photometry of planets: any simultaneous change affecting several planets being attributed to a variation in the sun. An example is given of Jupiter, indicating that it is partly self-luminous. (7) Photometry of the moon, and indirectly of the earth by means of the earth-shine. (8) Photometry of solar phenomena, such as faculæ, prominences, corona, and zodiacal light. (9) Photometry of sky for meteorological purposes, and of aurora. (10) Photometry of photographic plates.

W. W. B.

692. *Total Eclipse of Aug.* 21, 1914. **K. Bohlin.** Stockholm Observat., Astron. Iakt. 10. No. 4 [26 pp., in German], 1916.)—A detailed description is given of the instruments used for observing and photographing the corona and corona spectrum, with all calculations relative to the determination of the wave-lengths of the corona lines. The corona type was about the mean between the type for sun-spot maxima and that for sun-spot minima, but rather more like the latter. The photographs reproduced show marked similarity with those of Campbell for the eclipse of 1898, much less with those of the 1905 eclipse, and more again with the corona observed in 1908.

A. W.

693. *Kinematography at Solar Eclipse.* **E. B. Frost.** (Observatory, No. 539. pp. 215–216, May, 1919.)—To guard against the difficulty of choosing the exact moment for photographing the "flash" spectrum, Frost employed a moving-picture camera. A 3-prism train analysed the beam of light from the cœlostat. The camera lens was of 2-in. aperture and 16-in. focus, and 16 exposures per sec. were obtained for about a minute before and after totality, and a long exposure was taken for the corona during most of the period of totality, only the first five and last five seconds of totality being left for the kinematograph. The exposures, $\frac{1}{30}$ sec., were too long when the sky was clear, so $\frac{1}{50}$ sec. will probably be tried next time.

W. W. B.

694. *Diffraction Effects in Occultations by Planets.* **A. S. Eddington** and **J. W. Nicholson.** (Roy. Astron. Soc., M.N. 79. pp. 359–360, March, 1919.)—This deals with the validity of the usual assumption that gradual extinction of the light of a star by occultation is really an indication of an atmosphere round the occulting planet, having regard to the effect of refraction bands fringing the planet's shadow. As an example Mars is taken on

1918, April 11, when an occultation by it was observed in Australia, and the result points to a fading of the light from diffraction when the ray passes 200 metres above the surface, with a loss of nearly two magnitudes by the time it grazes. The conclusion is that this might be observable under very fortunate conditions in the case of a close graze, but normally it would be just below the limit of perception, while the effect of atmospheric absorption might be just above that limit. W. W. B.

695. *Orbit of Comet* 1802 (*Pons*). **K. Lundmark.** (Ark. för Mat., Astron. och. Fysik, Stockholm, 12. No. 13. pp. 1-53, 1917.)—The question whether this comet is identical with that of 1909 is also considered. No positive conclusion is arrived at although the differences in the orbit elements seem to render such identity improbable. L. H. W.

696. *Orbit of Comet* 1915*a* (*Mellish*). **L. Rosenbaum.** (Stockholm Observat., Astron. Iakt. 10. No. 5. [20 pp. French], 1917.)—The author's calculations lead him to the view that, in agreement with the observations of Schorr, Abetti, and Barnard, no single orbit will satisfy all the observations, and that it is indispensable to calculate two branches, the one applying to the single nucleus preceding division and the other to the divided nucleus. L. H. W.

697. *Families of Asteroids.* **K. Hirayama.** (Phys. Math. Soc. Japan, Proc. 1. (Ser. 3) pp. 52-59, March, 1919.)—Further note [see Abs. 1050 (1918)].—From a study of the mathematical probability the author concludes that resemblances between the elements of minor planets are not accidental, and proceeds to add four more to his previous list of families of asteroids, as well as six doubtful groups. The family "features" are (1) mean motion, (2) inclination of orbit to that of Jupiter, and (3) a constant relating to the eccentricities of asteroid and Jupiter.

The four new families given are associated with Iclea, Egeria, Flora, and Alice, and the doubtful ones with Atala, Fortuna, Vesta, Phocea, Victoria, and Ariadne, but a slight change of limits exchanges some members between the Themis and Flora families and includes the Alice family with the latter. W. W. B.

698. *Recent Changes on Jupiter.* **W. F. Denning.** (Observatory, No. 539. pp. 206-207, May, 1919.)—The author discusses the recent disappearance of the Red Spot Hollow and the South Tropical Disturbance, with a few notes on them and the Red Spot itself, and a suggestion as to the cause of its variable rotation period. He regrets that the older observers paid less attention to continuous measurement than more recent workers. W. W. B.

699. *Perturbations of Jupiter and Saturn with Mean Elements of the Planet* (236) *Honoria.* **B. Asplind.** (Ark. för Mat. Astron. och Fysik, Stockholm, 12. No. 2 [pp. 1-46, in Swedish], 1917.)

700. *Tables for Computing the Jupiter Perturbations of the Asteroids.* **G. Strömberg.** (Stockholm Observat., Astron. Iakt. 10. No. 3 [27 pp. in French], 1916). The asteroids dealt with in the present work are those of the *Flora* group (daily motion 1050"). Bohlin's method is employed (*ibid.* vol. 7, 1902). The *Minerva* group (daily motion 750") has already been dealt with by D. T. Wilson (*ibid.* 10, No. 1 [58 pp.], 1912), while the Jupiter

and Saturn perturbations of the minor planet Brunhilde (123) have been investigated by W. Hernlund (*ibid.* vol. 10. No. 2 [25 pp., in Swedish], 1918).
L. H. W.

701. *A Study of the Analysis of Stellar Motions.* **C. V. L. Charlier.** (Ark. för. Mat., Astron. och Fysik, Stockholm, 12. No. 10 [65 pp., in German], 1917.)—The author has made a study of the results yielded by six different methods for the analysis of the stellar motions. For the investigation the star field B_9 (constellation Cygnus) is chosen, being one of the 48 fields into which the sky has been subdivided (Lund Observat. Meddel. Ser. 2. No. 8). Since in the first three methods—namely, those of (1) a single stream, (2) an ellipsoidal stream, (3) two streams—the parameters of the distribution function can be derived, the six methods can be directly compared with one another. The other three methods are those of (4) the apparent proper motions, (5) the reduced proper motions, and (6) the linear velocities (obtained from stars whose apparent proper motions and parallaxes are known, whence the components of their linear velocities at right angles to the radius of vision can be derived). This last method is not included in the comparison table on account of its provisional character.

Method.	ω	θ_0	σ_1	σ_2	β	S_{30}	S_{03}	E_{40}	E_{04}
I. Single stream	2·25 Sir.	− 12·8°	3·73 Sir.		—	—	—	—	—
II. Ellipsoidal stream	,,	− 2·8	6·53	3·69	63·5°	—	—	—	—
III. Two streams	,,	(+ 18·2)	5·13	4·33	57·7	− 0·16	− 0·17	+ 0·02	− 0·02
IV. Apparent proper motions	,,	+ 13·6	5·90	2·50	55·7	− 0·61	− 0·26	+ 0·09	− 0·02
V. Reduced proper motions	,,	+ 29·3	6·17	2·96	62·9	− 0·51	− 0·19	− 0·10	− 0·05

In the above table the stream velocity ω is derived from the known motion of the sun, 2·25 siriometres per stellar year, and is used for all the methods. The stream direction θ_0, on the other hand, is calculated from the observations. β is the direction with respect to the vertex. The obliquities S_{30}, S_{03} are negative. The dispersion of the linear velocities amounts, as shown above, to about 6 siriometres in the vertex direction (σ_1), and about 3 in that at right angles thereto (σ_2), but obviously there is only one dispersion in method I.
L. H. W.

702. *Expansion of Cosmic Gas-sphere, Novæ, and Cepheids.* **A. Pannekoek.** (K. Akad. Amsterdam, Proc. 21. 5. pp. 730–742, 1919.)—The author distinguishes two classes of novæ—one with very short period of maximum followed by rapid decline and then by a period of fluctuation, the other with a long period of brightness, followed by irregular fluctuation and rapid decline. Examples of the first class are Nova Persei (1901) and Nova Aquilæ (1918), of the second, Tycho's Nova Cassiopeiæ (1572) and Nova Aurigæ (1892). Seeliger's explanation of Nova Aurigæ, a star passing through a nebula of varying density, does not fit the other type. The author thinks the adiabatic cooling is much more important than the loss of heat by radiation, which is largely compensated by gravitation. The high internal temperature will cause expansion outwards and the outermost layers which are coolest will be travelling outwards fastest, and will thus account for the dark absorption bands displaced towards the violet which are shown by novæ as soon as the luminosity falls off, indicating the cooling of the outer layer. The initial decrease is naturally slow, but is not shown because it is masked by the blazing up still in progress, so the author measures the falling-off in Nova Persei from a higher and earlier maximum than that actually observed. He finds that uniform expansion requires an almost uniform temperature throughout the mass, and that a nova at greatest brightness is very much larger, as well as more luminous, than the sun, with so small a density after a decrease of 4 magnitudes that light is emitted through the body, and so is measured, not by surface, but by volume. The paper discusses the question of orbital *versus* pulsation theory for Cepheid variables in the light of this suggestion. W. W. B.

703. *Tests of the Clockwork Drive of the Equatorials at the Babelsburg Observatory.* **H. Struve.** (Preuss. Akad. Wiss. Berlin, Ber. 32. pp. 655–668, 1918.)—The tests were carried out on the 65-cm. Zeiss refractor, of 10·4 m. focal length, and the Toepfer astrographic telescope (40-cm. photographic and 30-cm. visual objectives, of 5·4 m. focal length); the results are then compared with those previously obtained for the 13-in. Repsold refractor at Königsberg and the 30-in. Repsold refractor at Pulkova. The original paper must be referred to for the details of the observations. The Babelsburg telescopes are driven by clockwork provided with frictional centrifugal regulators of the Grubb type and having seconds' control; the Repsold telescopes, on the other hand, are fitted with a spring regulator (pendulum). The general conclusion arrived at is that the Repsold regulator without seconds' control is only very slightly inferior to the friction regulator with seconds' control; the friction type of regulator, when without the seconds' control, has a very variable speed and is thus quite unsuitable for more delicate micrometric or for photographic work. The most suitable combination would appear to be a regulator of the Repsold type, together with a seconds' control attachment similar to Grubb's. Special weight is attached to the production of a screw free from periodic error for the hour-circle drive: in this respect the slow drive in the Zeiss refractor is much to be preferred to the short-period drive of 1–2 minutes found in the other instrument. The instrumental errors are not disturbing for micrometric work, so long as these are of the same order as the refraction constants. But for photographic work the lateral deflection is considerable in large equatorials, and must be overcome by some load-relieving method, applied to the declination axis, such as is used by Grubb and by Zeiss. L. H. W.

704. *Second List of Spectroscopic Binaries.* **J. S. Plaskett** and **R. K. Young.** (Roy. Astron. Soc. Canada, J. 13. pp. 59–64, Feb., 1919.)—Contains a table of 18 binaries (additional to the 12 published in Nov.) showing for each its serial number, its number in Boss's catalogue, R.A., and Decl. for 1900, visual magnitude and spectral type, time, radial velocity, quality of plates, and discoverer (Plaskett or Young). Separate notes are given of the spectrum, etc., of each star, the data being sufficient to enable intending observers to decide on the character of the spectrum and its suitability for obtaining an orbit without making test plates. H. F. H.

705. *Photometric Observations of δ Cephei.* **E. Paci.** (Soc. Spettroscop. Ital., Mem. 7. pp. 8–18, Jan.–March–April, 1918.)—The light-curve in its ascent is more steep than in its descent, though the latter branch is much more irregular, and gives rise to an assymetrical appearance of the complete curve, whilst confirming the irregularity noticed by Argelander and Oudemans for the waning intensity. L. H. W.

706. *Spectroscopic Binary* 12 *Lacertæ.* **R. K. Young.** (Roy. Astron. Soc. Canada, J. 18. pp. 45–54, Feb., 1919.)—In the same class are β Cephei, σ Scorpii, and β Canis Major, all similar in having very short periods (4½–6 hrs.). In his 1918 measures, the author used 10-minute exposures with the 1-prism spectrograph on the 72-in. reflector. From the tabulated results it is shown that the amplitude varies between about 15 to 70 km. from night to night, the smaller amplitude being accompanied by more diffuse spectral lines, but the calcium lines remain always narrow and sharp with their amplitude smaller than the other lines. The velocity of the centre of mass, determined from the calcium lines, has the same variation from year to year as the other lines, showing plainly that the calcium causing the absorption is moving with the star, and that therefore it is probably in the form of a large cloud surrounding it. H. F. H.

707. *Absolute Magnitude.* (Observatory, No. 539. pp. 213–214, May, 1919.)—This note discusses the convention by which the definition of absolute magnitude is the magnitude at a distance of 10 parsecs, instead of the more logical 1 parsec, which would make the sun's absolute magnitude approximately zero. It is considered too late to make any change now, though it is uncertain whether Swedish publications conform to the now generally accepted convention. It is suggested that subsidiary units may be convenient, such as the kiloparsec. The tendency to refer magnitudes to the sun is deprecated, on account of the range in adopted values of the sun's absolute magnitude. W. W. B.

708. *Origin of Novæ.* **W. H. Pickering.** (Popular Astron., Nov., 1918. Nature, 103. p. 153, April 24, 1919. Abstract.)—The author discusses theories of the origin of novæ. Collision of star with star is rejected on the ground that there are too many novæ and they are all too speedy in their decline. Collision of star with nebula avoids the first objection but not the second, as years not days would be spent in traversing an ordinary-sized nebula. The author prefers an event like the falling of a planet into the sun, penetrating the photosphere and then exploding beneath it. The scattering of the materials of the photosphere would, he thinks, produce a very great, but short-lived, increase of brightness. The energy is not derived from the "planet," but from the "sun." W. W. B.

709. *Equilibrium Temperature of a Gaseous Star for any Radius.* **A. Véronnet.** (Comptes Rendus, 168. pp. 679–681, March 31, 1919.)—In a mass of gas like the sun, supposing the density uniform throughout, the temperature everywhere is higher than for any other hypothesis of equilibrium. Various relations between radius and temperature are given and limiting curves drawn. Taking the dilatation coefficient as constant and the central temperature as three times that of the surface of the nucleus, the resulting max. temperature is 75 million degrees, with a radius 25¼ times that of the sun and a density approximately that of hydrogen. Next allowing the dilatation to vary and taking the central temperature as only twice that of the surface of the nucleus, the max. temperature is 57 million degrees, with a radius 34 times that of the sun and a density less than that of hydrogen. After some more intermediary hypotheses, the ultimate conclusions point to a central pressure of 1000 atmos., involving at max. temperature intense ionisation and dissociation of molecules, with consequent diminution of molecular weight. The max. temperature being proportional to the molecular weight, is also thus reduced to 260,000°, when the mean molecular weight is unity. W. W. B.

710. *Photographic Magnitudes and Effective Wave-lengths of Nova Aquilæ* (1918). **A. S. Eddington.** (Roy. Astron. Soc., M.N. 79. pp. 361–362, March, 1919.)—The results were obtained at Cambridge Observatory from June 13 to Aug. 20, but wave-length determinations previous to June 28 have been rejected, on account of larger probable error, which was afterwards reduced, though even so the results are not considered good enough to establish a change of wave-length. For the photographic magnitudes α and β Aquilæ were used as comparison stars, the former only for the first three nights. Details are given of the exposures and method of standardisation.
W. W. B.

711. *Classification of Long-period Variables.* III. *Influence of Period on Shape of Curves in Phillips' Two Classes.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 79. pp. 371–382, March, 1919.)—Phillips' classification is slightly modified by assigning to Group I all stars for which the phase angle of the second harmonic is less than ±90°, and to Group II those in which it is greater. The characters of both groups then show relation to the period. For Group II multiples of 45 days show fluctuations, and so also does the "frequency" with which the stars occur at any particular period, but the coefficients of the harmonics do not show fluctuation, while changing steadily with the period. Frequency for Group I shows fluctuations in 60 days, but phases and coefficients vary gradually with period. The longest-period stars in both groups are in low galactic latitudes. [See Abs. 507 (1918).]
W. W. B.

712. *Further Observations of Nova Persei* (1901). **A. S. Williams.** (Roy. Astron. Soc., M.N. 79. pp. 362–366, March, 1919.)—Previous measures of the magnitude of this star were published in Vols. 61 and 62 of the Monthly Notices. The present paper carries on the work from Aug. 1902 to Dec. 1911, with a note that it was looked for in the autumn of 1918. The object of the continued search was to test the periodicity of the fluctuations of brightness, and the results indicate a period of about 55 days. The instrument used was a 6½-in. reflector, and probably the star is too near the limit of visibility for further observation. The magnitudes in the present paper go down to 12·3. W. W. B.

713. *Distribution of Stars of the 11th Magnitude.* **A. Pannekoek.** (Roy. Astron. Soc., M.N. 79. pp. 333–343, March, 1919.)—The author takes exception to Plummer's results [see Abs. 35 (1919)], on account of inaccuracy in the determination of the limiting magnitude for each chart, and of the decrease of star density with increasing distance from centre; especially for charts of great density centring in the Milky Way. He proceeds to apply corrections from a comparison of overlapping charts, and obtains a very different result. Plotting his values for the star density on a map or globe, he finds two regions of greatest density in the galactic zone, nearly opposite each other, but not corresponding with the brightest parts of the galaxy. There is a regular decrease with galactic latitude, and a variation with galactic longitude, indicating an ellipsoid with three unequal axes as the figure of distribution. By plotting the logarithmic deviations from a star density regularly decreasing with galactic latitude, the cause of this variation is shown to lie in two regions of deficiency, ranged about two opposite spots in Taurus and Ophiochus, where the star density is one-third or less of the normal value. This may be due to extensive absorbing nebulosities, or to a dark channel traversing our star system. W. W. B.

714. *Absorption Spectrum of Nova Geminorum.* II. 1912 *March.* **F. J. M. Stratton.** (Roy. Astron. Soc., M.N. 79. pp. 366–371, March, 1919.)—This is a preliminary note on the results of measurement of a series of spectrograms of Nova Geminorum, gaps in the Cambridge series being supplied from Allegheny and Bonn Observatories. The work was interrupted by the war, but striking results are expected and early notice is given with a view to preparation for similar work on Nova Aquilæ. The displacement of lines was at first represented by a shift of an α-Cygni spectrum towards the violet, the displacement diminishing daily for a time, and then a fresh outburst, giving a larger displacement, which again diminished. This at first only involved H-lines but afterwards enhanced Fe and Ti, and later still He lines shared the displacement. Later still the lines became more complicated, showing more than one pulse, and at the end of March, 1912, the appearance was represented better by two spectra of different pulses, one of α Cygni and the other of γ Orionis. This includes 66 lines in the nova, leaving 15, mostly weak ones, unidentified. The crucial evidence for the new identification is given by the complete correspondence with the well-known group of O and N lines between $\lambda\lambda$ 4600 and 4650. W. W. B.

715. *Hubble's Variable Nebula.* **V. M. Slipher.** (Lowell Observat. Bull. No. 81. Observatory, No. 539. p. 217, May, 1919. Abstract.)—A spectrogram obtained by 37 hours' exposure on N.G.C. 2261, agrees with that of R Monocerotis in the apex of the nebula, consisting mainly of bright enhanced iron lines, like early stages of novæ. There are other points of similarity to novæ, and it is probable that the star's light is reflected by the nebula. W. W. B.

LIGHT.

716. *A New Sector Spectrophotometer.* **S. J. Lewis.** (Chem. Soc., J., Trans. 115. pp. 812–819, April, 1919.)—Illustrated detailed description of an instrument specially designed for work on blood serum.

717. *Nature of the Surface Layers in the Reflection by Mercury.* **J. J. Haak** and **K. Sissingh.** (K. Akad. Amsterdam, Proc. 21. 5. pp. 678–692, 1919.)—In order to obtain the optical constants of a metal, quite independent of the grinding and polishing and of the material used for this purpose, mercury was chosen for this investigation. Both liquid mercury and a mirror of solid mercury were examined, so that any change in the optical constants due to the transition from the liquid to the solid state could be detected. In the investigation of liquid mercury it was found that the layers of air, which are condensed on the surface, exert an appreciable influence on the elliptical polarisation at reflection. The thickness of the adsorbed layer of air, and also its optical effect, was found to increase with the time. The thickness found for the adsorbed layer of air is about 1·6 $\mu\mu$, which is in agreement with the value for the transition layer liquid-vapour, for which Bakker gives 1–2 $\mu\mu$. No change in the optical constants of mercury was observed either on freezing or in subsequent cooling down to − 80° C. [See Abs. 1230 (1905).] A. W.

718. *Adjustment in Relation to the Fresnel Coefficient.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 120–125, April, 1919.)—This paper gives a preliminary investigation of the conditions desirable for observing fringes in reversed spectra obtained by one and by two internal reflections in a glass cylinder capable of rotation about its axis, which is normal to the ray-plane of the interferometer. A. W.

719. *Limits of Total Reflection.* **H. Krüss.** (Zeits. Instrumentenk. 39. pp. 73–83, March, 1919.)—Describes an investigation of the amount of light reflected from the surface of separation of two media, for various relative indices of refraction and for all angles of incidence from 0° to 90°. The results obtained are tabulated and also represented graphically. A. W.

720. *Colorimetric Measurements according to Ostwald's Scale.* **O. Meissner.** (Phys. Zeits. 20. pp. 83–85, Feb. 15, 1919.)—According to Ostwald [Abs. 926 (1917)] a colour may be expressed by 3 numbers each of 2 digits, such as 83, 13, 50, of which the first indicates the tone or number on his colour circle (00 yellow, 25 red, 50 blue, 75 green), the second *r* the whiteness, the third *s* the blackness. The measurements of the author were made with the aid of three Lambert mirrors of plane glass and of 3 colour-filters (red, blue, green). Some particulars are given of measurements made on German postage stamps of different colours (including the grey stamp, which has no tone), on flowers and leaves (green and autumn tints), and on some animals; the green of animals was found to have the characteristic numbers of chlorophyll. H. B.

721. *Optical Properties of Crystals in the Infra-red.* **T. Liebisch** and **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Ber. 16. pp. 198–219, 1919.)—Describes an investigation of the reflecting powers of various crystals in the long-wave part of the spectrum. Interesting curves are reproduced for all the substances dealt with. The following table, which includes observations by various other workers, shows the reflection maxima for the crystals used :—

Crystals.	Direction of Oscillation.	Short-wave Bands (μ).	Long-wave Bands (μ).
Quartz	‖	8·50, 8·70, 8·90, 9·05, 12·87	19·7, 27·5
SiO_2	⊥	8·50, 8·90, 9·05, 12·52	21·0, 26·0
Calcspar	‖	11·30	28·0, 94
$CaCO_3$	⊥	6·46, 6·96, 14·17	30·3, 94
Apatite	‖	—	32, (135)
$Ca_3(Cl,F)(PO_4)_3$	⊥	—	30, 45, (140)
Dolomite	‖	11·48	27·5, 68
$CaMg(CO_3)_2$	⊥	6·90	29, 74
Red tourmaline	‖	9·0, 12·75, 14·2	48, 97
	⊥	7·70, 10·1	48, 82
Barytes	*a*	8·93	62, 97
$BaSO_4$	*b*	—	61, (120)
	c	8·30	51, (130)
Celestine	*a*	8·84	48, 85
$SrSO_4$	*b*	9·05	58·5, (135)
	c	8·35	45·5, 84
Anglesite	*a*	—	68, (98)
$PbSO_4$	*b*	—	67, 97
	c	—	
Anhydrite	*a*	—	35, (45–50)
$CaSO_4$	*b*	—	35, (45–50)
	c	—	
Aragonite	*a*	11·55	36·5, (50), 85
$CaCO_3$	*b*	6·46, 6·70, 14·17	36·5, (50), 100
	c	6·65, 14·06	34, (50), 88
Cerusite	*a*	12·00	64, 94
$PbCO_3$	*b*	7·04	64
	e	7·28	64

A. W.

722. *Emission Theories and the Doppler-Fizeau Principle.* **F. Michaud.** (Comptes Rendus, 168. pp. 507–509, March 10, 1919.)—To explain the optical phenomena of moving bodies, we must either postulate a medium of propagation, the ether, in absolute repose (Lorentz-Einstein), or adopt the conception of emission (Ritz, J. J. Thomson and Stewart, Tolman). The hypothesis of Lorentz-Einstein necessitates a change in our ideas of time, space, mass, force, and temperature. The emissive theories have the advantage of not involving any changes of this kind. These theories are here discussed by the aid of simple algebraic formulæ. E. H. B.

723. *Optical Absorption.* **J. Holtsmark.** (Phys. Zeits. 20. pp. 88–92, Feb. 15, 1919.)—A discussion of the question of "general" and "selective" absorption, considered from the standpoint of recent electronic theory. An interesting comparison is made between the selective absorption in the visible spectrum and in the region of X-ray wave-lengths. Photographic illustrations are given. A. B. W.

724. *Atmospheric Scattering of Light.* **F. E. Fowle.** (Smithsonian Misc. Coll. 69. 3. [12 pp.] May, 1918.)—The atmospheric transmission coefficients obtained at Mount Wilson in the years 1910–1916 for the region of wave-lengths free from selective absorption (0·35–0·50μ) have been analysed. The transmission coefficient for dust-free dry air varies with the inverse fourth power of the wave-length. With a clear dry atmosphere at Mount Wilson the loss in transmission is apparently almost wholly due to molecular scattering and the number of molecules per cm.^{3} of dry air deduced from the scattering by the method suggested by Rayleigh is in excellent agreement with the best value obtained by other methods. The loss due to dust at Mount Wilson reached the enormous value of 25% for zenithal sun just subsequent to the eruption of Mount Katmai in 1913 but fell to about 1% in 1914–1915. When Rayleigh's method is applied to the scattering due to water-vapour in the atmosphere anomalous results are reached since the water-vapour should give 50-fold less absorption than that actually found. It is suggested that this large absorption may be due to some action of the sun's ultra-violet radiation upon the water-vapour and consequent formation of nuclei. Wilson has demonstrated by laboratory experiments that such action can take place. In support of this suggestion it is found that there are indications of a connection between the scattering produced by water-vapour in different years and both the sun-spot number and the radiation intensity. J. S. Di.

725. *Tyndall Beam and Size of Particles.* **R. C. Tolman, R. H. Gerke, A. P. Brooks, A. G. Herman, R. S. Mulliken,** and **H. De W. Smyth.** (Am. Chem. Soc., J. 41. pp. 575–587, April, 1919.)—Deals with the relation between the intensity of the Tyndall beam and the size of the particles. The authors find that increased subdivision results in increased reading of the Tyndallmeter. [See Abs. 516, 566, 567 (1919)]. E. H. B.

726. *The Colour of Water.* **W. D. Bancroft.** (Frank. Inst., J. 187. pp. 249–271, March, and pp. 459–485, April, 1919. Chem. News, 118. pp. 197–200, April 25; 208–212, May 2; 222–225, May 9; 233–235, May 16; 248–250, May 23, and pp. 254–256, May 30, 1919.)—A lengthy discussion of the present state of our knowledge on the subject. It is pointed out that the question at issue is whether Rayleigh's negative results are to outweigh Spring's positive results. L. H. W.

727. *Dispersion of Diamond.* **L. Silberstein.** (Phil. Mag. 37. pp. 396–406, April, 1919.)—The author's aim is to apply the concept of electrical interaction of atoms developed in previous papers [Abs. 772 (1917)] to the refractive properties of the diamond regarded as a known assemblage of fixed atomic centres, each containing a single dispersion electron and becoming a doublet in presence of an external electric field. In considering the infra-red free frequencies, the assumption of mutual immobility of the atomic centres must be abandoned, but in the case of the ultra-violet ones, the mobility can all be ascribed to the electrons. An indefinitely extended space-lattice of points is assumed to be occupied by the centres of equal atoms, each containing a single electron whose charge and mass are e, m. Let $e^2/m \equiv B$, and the vector p_i represent the electric moment of the doublet produced at the i-th centre by the electric force E of the incident light-wave (and by the co-operation of all the remaining doublets), γ the squared frequency of the incident monochromatic light, and γ_0 the squared frequency. The author starts with the vector equation of motion of the i-th electron, for any arrangement of centres, simplifies it by extending the summation over the remaining centres to infinity, and, in accordance with the opinion generally held, that *electromagnetic phenomena are influenced by particles of matter only so far as these contain electric charges.* He considers diamond, according to Bragg [Abs. 1268 (1915)], to consist of the superposition of two face-centred cubic lattices, one of which is derived from the other by translating it rigidly along a cube diagonal through one-quarter of the length of the diagonal, each point of both lattices being occupied by a carbon atom. The sum is then found to vanish, so that the resultant action of all doublets in an unlimited diamond lattice is *nil*, and the equation, for any i, simplifies to $(\gamma_0 - \gamma)\, p_i/B = E$, as if there were no interaction between the carbon atoms. Thus if μ is the refractive index, and N the number of carbon atoms per unit volume of the crystal, $(\mu^2 - 1)E = Np_i = Np$, or $\mu^2 = 1 + NB/\gamma_0 - \gamma)$. Then if λ be the incident wave-length (*in vacuo*), and λ_0 the free wave-length belonging to the electron of the carbon atom, $\gamma = 4\pi^2c^2/\lambda^2 \equiv 4\pi^2c^2u$, and $\gamma_0 = 4\pi^2c^2u_0$, where c is the velocity of light. Then if $a \equiv NB/4\pi^2c^2$, the dispersion formula becomes $\mu^2 = 1 + a(u_0 - u)$, that is, the simplest, two-constant formula of the common type. If therefore the assumptions are correct, this formula should represent the observed refractive index of diamond at least for not very long infra-red waves; and also for not too short ones, for which the assumed approximate homogeneity of E would no longer hold good. The observations of F. F. Martens on the diamond (Ann. d. Phys. 8. p. 459, 1902) with the wave-lengths of the Cd lines given by him corrected in accordance with Landolt-Börnstein's tables (1912) gives values of μ in almost perfect agreement, with the exception of Cd 467 ($\Delta\mu = -0{\cdot}0009$).

Now the atomic constant of carbon previously denoted (*loc. cit.* p. 527) by k_0, and whose immediate meaning is $k_0 = 1{\cdot}008/3\pi \,.\, e'/cm \,.\, e'/cm_H (e' = e/\sqrt{4\pi})$, has the value $k_0 = Ma/3d$, and if e' be the charge of an electron proper, the numerical value of k_0 is $\varepsilon = 1{\cdot}83 \times 10^{10}$ cm. gm.$^{-1}$. Now putting $M = 12$, and the density of diamond, $d = 3{\cdot}515$, the mean of the best measurements, and the value of a obtained from Martens corrected as above, makes $k_0 = 4{\cdot}07 \times 10^{10}$ cm. gm.$^{-1}$, which exceeds the nearest multiple, 2ε, of the proper electronic value by as much as $0{\cdot}22\varepsilon$. And it should be noted that the simplification, by assuming the crystal to be infinite, is physically equivalent merely to excluding from the investigation surface layers of thickness comparable with the elementary spacings. Moreover, if there were some interaction between the carbon atoms, the author shows that it would merely lower the free frequency, and so alter the value of u_0 without changing the type of the dispersion formula. G. W. DE T.

728. *Comparison of Flicker and Equality-of-Brightness Photometer.* **E. C. Crittenden** and **F. K. Richtmeyer.** (Bureau of Standards, Bull. 14. pp. 87–118, 1918.)—In connection with the proposed systematisation of heterochromatic measurements the work described was planned to show the difference to be expected between individuals and to include readings

by a large number of observers so as to establish average values for various measurements involving colour differences. The paper is divided into sections dealing with: Measurements on the Ives-Kingsbury solutions for selection of observers; measurements on blue glasses; other measurements by selected observers. The conclusion is reached that the system proposed by Ives and Kingsbury appears to be reliable for colour differences of the type dealt with in the tests. The average eye established is represented by approximately 0·99 for the ratio of the transmission of the yellow test solution to that of the blue solution. With regard to certainty of measurement the flicker photometer shows a decided advantage even with small colour differences. In regard to relative results there appears no room for doubt that for sources having relatively high intensity at the blue end of the spectrum the values given by the flicker photometer depart appreciably from those obtained with the Lummer-Brodhun, the difference being probably of the order of 3% at the higher efficiencies reached by gas-filled lamps. For the standardising laboratory, besides giving increased certainty, the flicker photometer reduces considerably the labour necessary to attain a given accuracy. L. H. W.

729. *Aerial Photometry.* **M. Luckiesh.** (Astrophys. J. 49. pp. 108–130, March, 1919: Frank. Inst., J. 187. pp. 289–312, March, and pp. 409–458, April, 1919.)—The data presented formed part of an investigation on the visibility of aeroplanes. Diagrams are given illustrating the relations of sunlight and skylight received on a horizontal surface during a clear day, and typical fluctuations from sunset to sunrise to sunset. The illumination on a horizontal surface due to the sun at zenith, outside the earth's atmosphere, is computed as 12,500 candle-ft. Data are next given for the apparent reflection factors of various objects: clouds and sky, woods, barren land, and inland water, etc. Owing to the irregularity of many earth-surfaces their reflection factor appears low (6 % for fields, 4·3 % for woods, and 11·3 % for barren land). Haze has commonly the effect of increasing the apparent brightness of such objects, as seen from above. The sky-brightness commonly varies between 0·5 and 2 lamberts. On the average, when observed from above, woods, water and fields appeared respectively to possess 0·45, 0·71 and 0·81 of the brightness B of zenith sky. Sunlit clouds, however, may attain 5–10 times B. The apparent brightness of inland water varies much according to the angle of view; it ranged, as a rule, between 0·05–0·1 B, while apparent coefficients of reflection of 3·5–7·4 % have been noted. In some instances suspended particles of solid matter affected the brightness and values for shallow water differed from those in mid-stream. J. S. D.

730. *Filming of Glass.* (Optical Soc., Trans. 19. pp. 184–185, June, 1918. Report of Discussion before the British Optical Instrument Manufacturers' Assoc.)—The following conclusions are given:—(1) Two kinds of film are met with: (*a*) more or less globular film which is alkaline, and (*b*) film which is largely organic in nature and due to condensation around nuclei (such as dust particles) or pits on the surface of the glass. (2) Usually the graticule is at fault, though this may be partly due to the fact that film on the graticule is in focus and therefore more noticeable to the observer. (3) In some instances film increases with time. (4) Generally speaking, glasses showing the greatest affinity for water give the most trouble. (5) The chemical constitution of the lubricants used is important. (6) Film is sometimes probably due to the presence of traces of HCl used in pickling the castings. J. W. T. W.

731. *Prevention of Film in Enclosed Optical Instruments.* **H. S. Ryland.** (Optical Soc., Trans. 19. pp. 178–179; Disc., 179–183, June, 1918.)—In every type of enclosed optical instrument are found instances, more or less frequent, of "film," *i.e.* the coating of lens and prism surfaces with what is apparently a thin deposit of moisture. The following precautions have been found to eliminate film completely:—(1) No japan or bitumen black to be used on interior surfaces. (2) No pitch or beeswax to be used within the case. (3) All interior surfaces to be thoroughly cleaned and free from animal matter, such as finger-marks. In the case of Al or similar porous metal, heat treatment is necessary after machining, to remove all trace of grease. (4) The lenses and prisms after ordinary cleaning to be dipped in hot running water with a pair of tweezers, and wiped dry with clean linen without being touched by the fingers again. (5) After washing the linen used for cleaning purposes it must be well rinsed in running hot water till all trace of soap has gone. (6) Dust must be removed with a clean camel-hair brush and not by blowing. (7) The linen used for cleaning must be used in such a way that no part of it which has been touched by the fingers is brought into contact with the lens or prism surface. (8) All surfaces must be well polished and free from "orange peel" effect. If the pitch polisher leaves a trace of scum, a small quantity of glacial acetic acid added to the pitch when melted will prevent it.

In the *discussion*, **J. W. French** considered that proper desiccation was the chief point to be attended to in the elimination of film, and suggested that $CaCl_2$ was the safest drying agent to use in instrument work. The complete but open binoculars should be placed in a stove connected in series with a pump and $CaCl_2$ container. The circuit should be a closed one, *i.e.* the same air should be circulated. After drying for 15 to 20 minutes (for a stove of 8-ft. capacity) the instruments should be kept in the neighbourhood of the dry air while being closed down preparatory to sealing. In the case of large optical instruments, desiccator connections should be provided, because, although instruments may be thoroughly desiccated and sealed before despatch, they may be opened in service.

C. Beck considered that the filming was largely due to particles of dust on which the moisture tended to condense. J. W. T. W.

732. *Selection of Glasses for Cemented Doublets.* **T. Smith.** (Optical Soc., Trans. 19. pp. 169–177, June, 1918.)—Describes a method of drawing-up and of using charts for the selection of suitable glasses for cemented doublets. By the use of such charts much time can be saved in calculating simple cemented objectives, since it is possible to ascertain beforehand that the glasses selected will be the most suitable of those that are available. Apart from such a method, only previous experience will enable a computer to avoid making calculations with a number of pairs of glasses, and after all obtaining no practicable result owing to the impossibility of meeting the various conditions that have to be satisfied with the pairs he has selected.

J. W. T. W.

733. *Striæ in Optical Glass.* **A. A. Michelson.** (Bureau of Standards, Bull. 15. pp. 41–45 [Sci. Papers, No. 333], 1919.)—Striæ in optical glass may be divided into two classes; (i) those which appear as isolated bright streaks on a dark background, and (ii) those in which such bright streaks are very numerous and run into one another. This paper describes the investigation of a specimen of the former variety, containing a single approximately plane and very narrow stria—resembling a crack in the glass—which was ground and polished so that the stria was approximately perpendicular to the polished plane-parallel surfaces. The total reflection intensities showed that the stria was caused by a film of refractive index approximately 0·005 smaller than that of the remainder of the glass. It results, therefore, that isolated striæ are of no more importance than are the bubbles found in some of the best telescope objectives. In the case of striæ of the second class, however, it is not desirable to attempt to utilise such glass for optical purposes where a high resolving power is required. Nevertheless, for binoculars, gun-sight telescopes, periscopes, etc., such glass may give excellent results if the planes of striation are perpendicular to the line of sight. Such glass should not, however, be used for prisms. J. W. T. W.

734. *Lenses for Aerial Photography.* **W. B. Appleton.** (Phot. J. 59. pp. 114–121, April, 1919.)—Describes the problems met with in the design of lenses for aircraft cameras, and shows how these have been overcome in practice. **J. Hasselkus.** (*Ibid.* pp. 121–122, April, 1919.)—Hasselkus points out the necessity for correction for coma and states that lenses well corrected for sine condition are not necessarily free from coma if they are of great aperture and considerable covering power. **A. C. W. Aldis.** (*Ibid.* pp. 122–127; Disc., 127–129, April, 1919.)—Aldis describes the difficulties met with in the manufacture of large anastigmats, and gives some details as to the time involved in the calculation of a lens, the methods of testing, etc.
J. W. T. W.

735. *Night Glasses.* **L. C. Martin.** (Dept. of Scientific and Industrial Research, Advisory Council, Bull. No. 3. [39 pp.], 1919.)—Describes an investigation of the various factors affecting the performance of binoculars for use at night. The points investigated include adaptation of the eye, visibility of a source of variable brightness at different distances, the effect of background, diffuse light, size of field, etc. It is concluded that for a hand instrument a power of 5 or 6 with an exit pupil of 7 to 8 mm. will probably give the best results, while for a stand instrument a power of 10 may be used. J. W. T. W.

736. *Some Generalised Forms of Optical Equation.* **T. Smith.** (Optical Soc., Trans. 20. pp. 23–35; Disc., 35–36, Nov., 1918.)—The paraxial equation for refraction at a spherical surface connecting conjugate points on the axis may be made an exact relation for all rays by the inclusion of an additional factor. All the angles required to specify a ray may be expressed in terms of three angles, some one of which vanishes when the rays pass through any one of the three pairs of conjugate points at which there is freedom from aberration. The additional factor to be introduced is the product of the tangents of the halves of any two of these three angles, and three exact equations of refraction are thus found. The correcting factor has only to be known approximately to enable the refraction of the ray to be determined to a high order of accuracy. When rays are to be traced through a series of surfaces the most convenient form of the equation at each surface is $\mu'/(x'-p)-\mu/(x-p)=(\mu'-\mu)/(r-p)$, where p may be regarded as a correction to the radius of curvature and as a displacement of the effective unit point. AUTHOR.

737. ***Calculation of Telescope Objectives free from Chromatic and Spherical Aberrations.*** **S. D. Chalmers.** (Optical Soc., Trans. 18. pp. 183–196; Disc., 196–214, May, 1918.)—The method used in the calculations is to obtain approximate expressions for the various aberrations, by neglecting the effects of thickness and the higher order aberrations. From these expressions approximate curves are deduced, these curves are checked by trigonometrical calculations and the various errors estimated. The approximate expressions are then used to calculate the changes in the curves to correct these errors. If necessary the curves are again checked by trigonometrical methods.

The trigonometrical calculations follow very closely the methods described by Steinheil and Voit, except in a few minor points. L. H. W.

738. *On the Design and Testing of Telescope Objectives.* **P. F. Everitt.** (Optical Soc., Trans. 18. pp. 142–159, May, 1917.)

739. *First Approximation Relations in Centred Optical Systems.* **S. D. Chalmers.** (Optical Soc., Trans. 18. pp. 122–137, April, 1917.)

740. *More Notes on Glass Grinding and Polishing.* **J. W. French.** (Optical Soc., Trans. 18. pp. 8–35; Disc., 35–48, Jan.–Feb., 1918.) [See Abs. 40 (1917).]

741. *The Grading of Carborundum for Optical Purposes.* **J. W. French.** (Optical Soc., Trans. 19. pp. 2–21; Disc., 21–37, Oct., 1917.)

742. *Optical Method for Accurately Dividing a Circle into Degrees.* **R. S. Clay.** (Optical Soc., Trans., 18. pp. 237–240; Disc., 240–242, June, 1917.)

743. *Trigonometric Computation Formulæ for Meridian Rays.* **P. V. Wells.** (Washington Acad. Sci., J. 9. pp. 181–184, April 4, 1919.)—Proposes a system of notation designed to simplify optical computations. J. W. T. W.

744. *Einstein's Theory and Fermat's Principle.* **T. Levi-Civita.** (N. Cimento, 16. pp. 105–114, Sept.–Oct., 1918.)—Claims to have succeeded in establishing mathematically, and in a still simpler manner than Weyl, the two principles of geometrical optics, namely: geodetics (4-dimensional), and least time. L. H. W.

745. *Mechanical and Osmotic Actions of Radiation on the Media passed through. Theory of Photophoresis.* **F. Michaud.** (Comptes Rendus, 168. pp. 770–772, April 14, 1919.)—A mathematical and general discussion of the movements of ultra-microscopic particles under the action of light which have been experimentally studied by Ehrenhaft. [See Abs. 1085 (1918).] E. H. B.

746. *Sensitiveness of Photographic Plates to X-rays.* **N. C. B. Allen** and **T. H. Laby.** (Nature, 103. p. 177, May 1, 1919. Abstract of paper read before the Roy. Soc. of Victoria, Aug., 1918.)—Although observations have been published on the effect of X-rays upon photographic plates, the constants of various plates in use do not appear to have been determined. These experiments follow the standard methods of sensitometry of photographic plates to light in respect of exposure of the plate in strips, of development at a standard temperature and for a constant period (namely, hydroquinone at 20° C. for 4 mins.), and of the subtraction of the density of a fog strip. The density, *i.e.* the log. to base *e* of the ratio of the intensity of the incident to that of the transmitted light, is determined by a polarisation photometer. The "exposure" E is defined by the relation $E = V^2 it/d^2$, where V (in volts) is the pressure applied to the Coolidge tube; *it* the quantity of electricity (in coulombs) passing through the tube during the exposure of *t* secs.; and

d the distance (in cm.) of the focal spot from the photographic plate. This expression gives the energy of the incident rays. Three values for V were used: 81,500, 78,000, and 88,000. The current varied between 0·08 and 0·06 milliamp., which is lower than the currents ordinarily used in radiography. Experiments are in progress using higher intensities of radiation.

When the density D of a given plate is plotted against the log. of the exposure as above defined, a curve similar to those of Hurter and Driffield is obtained. For densities from 0 to about 1 the curve is convex to the log E axis; above this it is straight to densities of 4, the maximum measured. The intercept on the log E axis of the straight line produced backwards is the log. of the inertia of the plate, which is found to be independent of the development. This result is the same as for exposure to visible light. The slope of the straight portion of the curve gives the contrast. A high value for the contrast is one of the desirable properties of an X-ray plate. The "speed" of a plate may be tentatively defined as the reciprocal of the exposure required to produce a density of 5. The density produced in a given plate is found to be constant for a constant value of the exposure V^2it/d^2 over the range V 81,500 to 88,000, and for a limited variation of i and t, but not for a large variation of i and t. This means that, for the wave-length used, the density of the plate depends, not on the wave-lengths, but only on the energy of the X-rays.

Plate.	Inertia.	Contrast.	Speed.
Paragon	$0·74 \times 10^3$	2·4	0·00017
Paragon	1·18	2·3	0·000096
Diagnostic	0·71	2·2	0·00015
Sunic	1·00	2·35	0·00012
Seed	1·12	1·9	0·000066
Wratten	1·95	2·2	0·000052
Wellington	1·70	2·0	0·000050
Imp. X-ray	1·26	1·6	0·000036
Cramer	2·14	1·9	0·000035
Ilford	2·19	1·9	0·000033
Imp. S.R.	1·45	1·55	0·000028

A. E. G.

747. *The Reticulation of Gelatine.* **S. E. Sheppard** and **F. A. Elliott.** (Eastman Kodak Co.'s Research Lab., Com. No. 71. J. Ind. and Eng. Chem. p. 727, Oct., 1918. Frank. Inst., J. 187. p. 227, Feb., 1918. Abstract.)—The production of reticulation is ascribed to localised release of normal, *i.e.* lateral, swelling of the gelatine layer on plate or film. Normally the gelatine layer swells and shrinks almost entirely in the direction perpendicular to the support. If it is treated with reagents (or under conditions of temperature) so that an excessive swelling is produced, it may strip off the plate. If the excessive pressure is restrained by tanning agents, it may easily happen that the restraint is not uniform. In consequence, there is localised excessive swelling and shrinkage adjacent to each other, the net result of which is the reticulation pattern. At the same time, if developed silver grains are present in the film, these aggregate in the more swollen portions, leaving the less swollen parts poorer in silver. It is pointed out that excessive "graininess" in developed images is very probably due to incipient or latent reticulation.

L. H. W.

748. *The Watkins Factor.* **S. E. Sheppard.** (Phot. J. 59. pp. 185–187, April, 1919.)—Whilst the conclusions reached by Kingdon [Abs. 291 (1919)] and others indicate agreement that the differences in diffusion alone are insufficient to account for the wide variations in the Watkins factor, no positive explanation seems to have been advanced. In the present paper certain stages in the theory of development reached by the author and his co-workers are outlined. The theory thus far developed is inadequate in certain respects. From considerations given it would follow that the higher the reduction potential, the smaller the bromide depression and initial induction, and, therefore, the higher the Watkins factor. It is questionable, however, if this is sufficient to account for the wide individual variations of that factor, nor will the view that the average velocity-constant is solely determined by diffusion agree with the very considerable differences, for k with different reducers, and with the difference in the temperature coefficients. Further, it does not account for the deviations, observable with high Watkins' factor developers, of the development (γ, t) curve from the simple function found to hold for low-factor developers. Particularly with the high-factor developers the velocity falls off more rapidly in the latter stages than this function indicates. The explanation of these anomalies may be found probably in the intervention of selective adsorption and intermediate complex formation between silver ions, reducer and silver halide. Deviations in the latter stages of development from the simple exponential function are not at once accounted for. They may be due partly to a depletion of the lower layers more rapidly than diffusion can re-supply, partly to a paralysing effect of reaction products, particularly colloidal oxidation products of organic developers. In any event the final stage in the chemical reactions conditioning building up of silver grains and growth of density is the discharge of silver from supersaturated solution. It is well known that in electrolytic deposition, and in reduction in homogeneous solution, the rate of reduction and nature of deposit is markedly affected by protective colloids, and such influences may be expected to be at work in development. A fuller experimental discussion is to follow later. A. E. G.

749. *Form of Mirror for Complete Polarisation.* **F. Jentzsch-Gräfe.** (Deutsch. Phys. Gesell., Verh. 20. pp. 108–109, Aug. 30, 1918.)—Shows that, for monochromatic light the form of mirror required for complete polarisation of light radiating from a point is given by the equation: $x^2+y^2+z^2=e^{2b \tan (y^2+z^2)^{1/2}/x}$, where the point itself is taken as the origin. J. W. T. W.

750. *Spectrum of Neon.* **K. W. Meissner.** (Ann. d. Physik, 58. 4. pp. 838–874, March 14, 1919.)—A continuation of previous work [Abs. 228, 224 (1917), and 265 (1918)]. The author has shown that in the neon spectrum there are numerous lines in the region 7900–9000 Å.U. Wave-length measurements of these lines have now been completed, and the results are given in the present paper. It is shown that these lines (75 in number) exhibit numerous groups with constant frequency differences, and that they can be arranged in several series. These series are presented in tabular form. A. W.

751. *Regularities in the Spectra of Lead and Tin.* **R. V. Zumstein.** (Roy. Soc. Canada, Proc. 12. pp. 59–68, June and Sept., 1918.)—An examination of the work of Kayser and Runge, and of some unpublished researches of

Fuller and Ainslie has shown that in the spectrum of lead a symmetrical group of three lines repeats itself five times, giving five groups with constant frequency differences. Of these, groups I, II, and IV correspond with groups of lines discovered by Kayser and Runge and added to by Saunders [Abs. 775 (1916)]. Flame spectra of lead show that the lines λ4058, λ3684 and λ3640 are fundamental, and λ2833 is also persistent. Experiments on the absorption due to lead vapour point to the possibility of the lines λλ7729·30, 4057·97, 3683·60, 3639·71 and 2833·17 being similarly related to the lead spectrum—being, in fact, the heads of analogous groups of lines. Similar results have been obtained with tin, a group of three lines being repeated five times with constant frequency differences. Of these groups, groups IV and V are new. A. W.

752. *Bohr's Theory of Spectra and Inelastic Collisions between Slow-moving Electrons and Gas Molecules.* **J. Franck** and **G. Hertz.** (Phys. Zeits. 20. pp. 132–143, March 15, 1919.)—This paper gives a *résumé* of the work of many investigators on the relation between the spectra of numerous substances and inelastic collisions between slow electrons and gas molecules. Discussion of the results leads to the establishment of Bohr's theory on a firmer basis, and shows how investigation of such inelastic collisions may help greatly in the work of arranging lines in their proper series. A comprehensive list of references is included. [See Abs. 523 (1919).] A. W.

753. *Broadening of Spectral Lines.* **J. Holtsmark.** (Phys. Zeits. 20. pp. 162–168, April 1, 1919. Ann. d. Physik, 58. 7. pp. 577–630, May 9, 1919.) —A theoretical treatment. It is found that when the atoms (or molecules) are ions, the half-breadth of the line is proportional to the 2/3 power of the density. When the molecules are dipoles the breadth is proportional to the density itself, and when the molecules are tetrapoles the breadth is proportional to the 4/3 power of the density. The breadth is also proportional to the displacement, in the Stark-effect, for unit field strength. A. W.

754 *Molecular Electric Field in Gases.* **P. Debye.** (Phys. Zeits. 20. pp. 160–161, April 1, 1919.)—Stark has attributed the broadening of spectral lines due to pressure to the effect of electric molecular fields. The present paper gives calculation relating to the magnitude of such molecular fields. For such gases as NH_3, SO_2, etc., at atmospheric pressure it is found that the molecular field is of the order of 4×10^4 volts/cm., while in the case of nitrogen or oxygen the molecular field is of the order of $1{\cdot}2 \times 10^3$ volts/cm. [See Abs. 625 (1919).] A. W.

755. *X-ray Spectra.* **A. Muller.** (Archives des Sciences, 1. (Ser. 5) pp. 127–132, March–April, 1919.)—Investigations on X-ray spectra have already given interesting results from the point of view of atomic theories—the numerical relations existing between the characteristic wave-lengths of different elements have been interpreted by the theory of Bohr-Sommerfeld. With regard to the mechanism of excitation of X-rays, the relation existing between the continuous spectrum and the characteristic radiation, and the distribution of energy in the spectrum, very little convincing work has been done. Lilienfeld [Abs. 301 (1919)] concludes, for example, that the material of the antikathode has apparently no influence on the continuous spectrum emitted by an X-ray tube. On the other hand, Ulrey [Abs. 842 (1918)] obtains the opposite result, namely, that the antikathode material exercises a very pronounced influence on the radiation.

The author now describes experiments in which he verifies the law of Einstein and makes different observations on the relation existing between the continuous spectrum and the characteristic radiation. A photographic method is employed and excellent photographs are shown in illustration. These show clearly how the limiting frequency of the continuous spectrum changes with the potential applied to the tube. Using Einstein's relation, giving the minimum potential required to produce X-rays of a given frequency in terms of Planck's constant, the mean value $h = 6{\cdot}60 \times 10^{-27}$ erg sec. $\pm\frac{1}{2}\%$ is deduced from the observations. A. B. W.

756. *The Origin of X-ray Spectra and the Constitution of the Atom.* **L. Vegard.** (Phys. Zeits. 20. pp. 97–104, March 1, 1919.)—A mathematical paper dealing with the distribution of electrons in the atom on the basis of well-known X-ray data and Planck's quantum *h*. Tabulated values of the characteristic X-ray frequencies of various elements show good agreement between observation and theory. If detailed information is required the original paper should be consulted, in addition to earlier papers by the author on the same subject. [See Abs. 530 (1918).] A. B. W.

757. *Investigation by Means of X-rays of the Crystal Structure of White and Grey Tin.* Parts II and III. **A. J. Bijl** and **N. H. Kolkmeijer.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 494–500, and pp. 501–504, 1919.)—Mathematical examination of the results described in [Abs. 346 (1919)] indicates that white tin crystallises in the tetragonal system, while grey tin forms octahedral crystals belonging to the regular system. The space-lattices indicate that grey tin is tetravalent, while white tin is divalent. F. C. A. H. L.

RADIO-ACTIVITY.

758. *Prot-Actinium and the Life of Actinium.* **O. Hahn** and **L. Meitner.** (Phys. Zeits. 20. pp. 127–130, March 15, 1919.)—In a previous paper [Abs. 951 (1918)] the authors announced the discovery and isolation of a new radio-active element, which they called Prot-actinium, this substance being the long-sought-for parent of actinium. The new element, a higher homologue of tantalum, emits α-rays of 3·14 cm. range and its half-value period lies between 1200 and 180,000 years. The growth of actinium from the free prot-actinium was demonstrated by measurements of the α-ray activity changes, as well as by observations on the growth of emanation and active deposit. The present paper describes an investigation of the half-value period of actinium —this constant being determined by two different and independent methods. In the first method the growth of actinium from a pure specimen of prot-actinium was observed, whilst in the second method direct observations were made on the decay of pure actinium. The results of the two methods are in good agreement and give an average value of 20 years ± 10% for the half-value period of actinium. A. B. W.

759. *Chemical Action by Radium Emanation.* I. *Combination of Hydrogen and Oxygen.* **S. C. Lind.** (Am. Chem. Soc., J. 41. pp. 531–551, April, 1919.)—Determining in 1911 the amount of ozone formed in oxygen by α-rays, the author found that one molecule of ozone was formed per two pairs of gaseous ions. From the data of Cameron and Ramsay and others available on ionisation by α-particles, he concluded that the ionisation and the resulting chemical action are of the same statistical order (ion for molecule), and

illustrate a modified form of Faraday's law. Krueger and Moeller determining by ultra-violet absorption the ozone formed by the passage of electrons of high velocity through oxygen had found one molecule per pair of ions. But according to Scheuer 3 molecules of H_2O are formed by α-particles from the gases per pair of ions, and according to Wourtzel the chemical reaction is still more in excess of the ionisation in various other reactions. The author hence repeated the experiments of Cameron and Ramsay concerning the action of radium emanation on hydrogen and oxygen, using spherical vessels of different diameters (1 to 5·5 cm.) and also cylinders.

The velocity of reaction, he finds, depends only on the gas pressure and the quantity of emanation. The velocity constant of the reaction diminishes with increasing diameter; the velocity constant is raised by an excess of oxygen and lowered by an excess of hydrogen, and both these gases must hence be activated by the emanation; the temperature coefficient of the reaction is zero between 0° and 25°. Calculation of the ionisation by the method of average path of the α-particles shows that for each pair of ions produced in the gas mixture 3·9 molecules of water are formed. Thus Scheuer is confirmed; yet the kinetic conclusion of the author is maintained. The discrepancy is ascribed to the fact that Cameron and Ramsay did not measure their emanation *in loco*, but calculated it from the amount of radium employed and the time of accumulation.

II. *Chemical Effect of Recoil Atoms.* (*Ibid.* pp. 551–559, April, 1919.)—In the experiments the velocity of combination is deduced from the observations of the reduction in the gas pressure at constant volume. The reaction velocity depends upon the pressure and the amount of emanation E; but P is a function of E, and the kinetic equation found to hold for large spheres was inapplicable to small spheres of 1 cm. diam. This is explained on the assumption that the recoil atoms produced chemical action proportionate to their ionisation just as the α-particles themselves do. In the small spheres the rate of combination was found abnormally high, especially at low gas pressures (down to 5 mm. Hg. when the reaction velocity rose to 6 or 7 times the normal). The results are in general agreement with Wertenstein's ionisation data for recoil atoms. In an addendum the author refers to exceptional cases, notably the combination of hydrogen and chlorine, in which the rate of chemical action seems to be enormously high, a thousand times the rate of the ionisation. H. B.

760. *Radio-activity of the Natural Gases of Canada.* **J. Satterly** and **J. C. McLennan.** (Roy. Soc. Canada, Trans. 12. pp. 153–160, Dec., 1918, and March, 1919.)—For reasons both of a theoretical and practical nature the authors considered it advisable to make a systematic survey of the natural gases of the whole of the Dominion of Canada, examining all the gases for their radio-active properties and helium contents, in the hopes of establishing relations between these two factors and also, possibly, between these and the nitrogen content. No direct relation has been established, however, between the radio-activity and either the helium and nitrogen contents, but it is found that helium and nitrogen usually vary together; *i.e.*, when one is high the other is high.

After describing the method of investigation, the authors give tabulated results of their analyses of a large number of "natural" gases obtained from various parts of Ontario and Alberta. A. B. W.

HEAT.

761. *Measurement of very Low Temperatures.* **XXIX.** *Vapour-pressures of Oxygen and Nitrogen for obtaining Fixed Points on the Temperature-scale below 0° C.* **P. G. Cath.** (K. Akad. Amsterdam, Proc. 21. 5. pp. 656–663, 1919. Comm. No. 152*d*. from the Phys. Lab., Leiden.)—The measurements recorded in previous papers [Abs. 957, 959 (1918)] in conjunction with Onnes and Burgers offered the opportunity of making some determinations of vapour-pressures of oxygen and nitrogen with the apparatus already fitted up for constant-temperature work. Onnes and Braak have already added the boiling-point of oxygen and a couple of lower points to the available fixed points on the temperature-scale, and the present determinations are intended to supplement these and serve for obtaining an independent calibration of the oxygen- and nitrogen-vapour-pressure thermometers. Section 2 of the paper contains details of the determinations, while section 3 gives tables of results. Finally the author has tried to connect his data with Crommelin's measurements between the boiling and critical points. He finds the latter may be represented satisfactorily by the equation: $T \log p = A + B(T - T_k) + C(T - T_k)^2$, where $A = 190{\cdot}86$, $B = 3{\cdot}9649$, and $C = 0{\cdot}00100$ for p in atmos. H. H. Ho.

762. *Formula giving the Density of a Fluid in the State of Saturation.* **E. Ariès.** (Comptes Rendus, 168. pp. 714–717, April 7, 1919.)—This paper is a supplement to a whole series of previous communications. The nomenclature remains the same as in preceding papers. The formula giving the density of a fluid in the state of saturation is found to be:

$$\nu_1 - \nu_3 = (RT_c/8P_c)T(y_1 - y_2) = (RT_c/8P_c)(x - 1/\tau^{n+1})(y_1 - y_2).$$

At temperatures sufficiently removed from the critical point, the volume ν_1 of the vapour is considerably greater than the volume ν_2 of the fluid condensed to the liquid state, and in consequence the latter becomes practically negligible, so that the expression gives the density of the saturated vapour. This formula presents a very interesting feature, namely: The tension P of the saturated vapour of a pure substance at a given temperature T determines the values of x, y_1, y_2. From the formula the difference $\nu_1 - \nu_2$ for this temperature may be deduced when T_c, P_c and n are known. Conversely if the vaporisation tension be known and the molecular volumes ν_4 and ν_2 the formula enables the true value of n to be found, since this only depends on the critical constants T_c and P_c. A comparison is made with experimental data for carbonic acid, stannic chloride, methyl formate, and heptane, with excellent agreement. H. H. Ho.

763. *Coefficient of Total Radiation of a Uniformly Heated Enclosure.* **W. W. Coblentz.** (Washington Acad. Sci., J. 9. pp. 185–187, April 4, 1919.)—A note on a previous paper by Kahanowicz [see Abs. 288 (1918) and 699 (1916).] J. W. T.-W.

764. *Physical Properties of Petrol Vapour.* **J. Rey.** (Comptes Rendus, 168. pp. 509–513, March 10, 1919.)—Discusses the gas equations for petrol vapour. E. H. B.

765. *Heat of Dissociation of Diatomic Gases in Connection with the Increased Valency-Attractions* $\sqrt{A}$ *of the Free Atoms.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 21. 5. pp. 644–655, 1919.)—In a series of previous communications [Abs. 75 and 810 (1918)] on the additivity of the values of b and $\sqrt{(a)}$ of the equation of state, and on the fundamental values of these quantities for different elements in connection with the periodic system, the author determined values for $b \times 10^5$ and $\sqrt{(a)} \times 10^2$, tables of which are here included. These fundamental values present a great regularity: starting from the carbon group, the decrease in every horizontal row of the periodic system towards the right is 15 units, and in every vertical row the decrease downwards is 55 units. The elements of the valenceless helium group fit in with the elements of the preceding halogen group in a natural way. All the values of b can now be built up additively by the aid of these fundamental values for the most divergent compounds. No exceptions have been found to this additive law, those that still existed for a few organic substances (*e.g.*, the amines) having now all disappeared owing to later determinations of T_k and p_k by Berthoud. The values of b found are entirely independent of the state in which the atom exists: whether as free atom, *e.g.* in metallic tin, or as part of a molecule as in $SnCl_4$. This is found not to be case with the fundamental values of $\sqrt{(a)}$. When the central atom, for instance C in CH_4, is surrounded on all sides by atoms or groups, the value of $\sqrt{a} = 0$ everywhere, so that these enclosed atoms do not exert any attractive action towards the outside. As soon as the C-atom gets partly free again, by double bindings, as for instance C in C_2H_4, the value of $\sqrt{(a_A)}$ rises from 0 to 1·55, and when entirely free, *e.g.*, for triple bindings in C_2H_2, the full value 8·1 is accordingly at once found. This rule holds everywhere. When the atoms no longer occur in compounds, as N in N_2, Cl in Cl_2, etc., but can occur entirely free, as for metals or for the free atoms Cl, Br, I, at high temperatures, then the values of $\sqrt{(a)}$ rise at once to the greatly increased values $\sqrt{(A)}$ of 30 to 40 (instead of from 1 to 11). These increased values are therefore the real valency-attractions, whereas the values found in compounds represent only the so-called rest-values, *i.e.* what still remains for action outside, after the chief valencies are saturated. For the elements of the helium group only the ordinary rest-values are found in spite of their atomistic behaviour, and is due to these elements being valenceless. Similarly for the C-atom, which accounts for the enormously high value of its critical temperature, namely 6500° abs., as against 120° abs. for the case of C_2.

The subject of the present paper is the calculation of the heats of dissociation from the values of the increased valency-attractions $\sqrt{(A)}$. It is found that the heats of dissociation on the decomposition of the molecules H_2, N_2, O_2, Cl_2, etc., into their atoms, are perfectly accounted for by the increased valency-attractions $\sqrt{(A)}$ of the separate atoms as found by the author in earlier papers. The author points out that these values must be known completely in order to elucidate the behaviour of chemical substances reacting on each other. H. H. Ho.

766. *Some Conclusions Arising out of the So-called Degradation Theory of Gases.* **W. Nernst.** (Preuss. Akad. Wiss. Berlin, Ber. 8. pp. 118–127, 1919.)—Quanta theoretical considerations as well as the application of recent heat hypotheses lead to the result that at very low temperatures the equation $pV = RT$, for the perfect gas, is invalid, since the gas is in such a condition that at constant volume, the pressure is independent of the temperature. This constitutes the so-called degraded state of the gas. The gas now appears to behave in many respects like a solid, whether crystalline or amorphous. Although in the case of solids it must be assumed that even at zero pressure the smallest particles are a definite distance apart, and that on compression impact forces occur, while with dilatation attractive forces appear, yet gases behave as if only impact forces were present, and the characteristic of a gas remains—namely, that it fills any space presented to it to a uniform density. The author opines that only his own equation of state for gas degradation is in agreement with current data, and this is now used for the deduction of further consequences. The equation of state is: $p=\frac{R}{V}\cdot\frac{\beta\nu}{1-e^{-\beta\nu/T}}$, ($\beta=h/k'=4{\cdot}868\times10^{-11}$, $Nk'=R$), wherein ν is determined by the relation $\nu=hN^{2/3}/4\pi mV^{2/3}$ (N is the Avogadro number $=6{\cdot}17\times10^{23}$, h is Planck's constant $=6{\cdot}55\times10^{-27}$, m is the mass of the molecule). The conclusions drawn are that the phenomenon of gas degradation becomes explicable when relatively weak impact forces of a valency character are assumed to act between homogeneous molecules. These forces are inversely proportional to the third power of the distance apart and also to the mass of the respective molecules. Since these forces are also manifested during impact of two molecules, the free paths and the phenomena connected therewith are calculable by a new set of formulæ based upon the feeble character of the forces at very low temperatures, and the very small molecular velocities. In the case of hydrogen at very low temperatures, the viscosity has been determined to a sufficient approximation solely from the mass of the hydrogen molecule, its molecular velocity, and Planck's constants. An indirect experimental ratification of the phenomenon is included in the paper.

H. H. Ho.

767. *Influence of Temperature on Homogeneous Gas Reactions.* **G. W. Todd** and **S. P. Owen**. (Phil. Mag. 37. pp. 224–230, Feb., 1919.)—(1) From Maxwell's ditribution theorem is deduced a simple expression for the number of gas molecules per cm.^{3} having velocities greater than a particular value.

(2) Assuming that only molecules with kinetic energies greater than a definite minimum have the power to react with other molecules, it is shown how the "velocity constant" of a gaseous reaction varies with the temperature.

(3) The usual form of expression for the variation of the "equilibrium constant" with the temperature is obtained. L. H. W.

768. *Air and the Law of Corresponding States.* **A. L. Clark.** (Roy. Soc. Canada, Trans. 12. pp. 47–50, June–Sept., 1918.)—The paper commences with a discussion of van der Waals' equation, and the reduced equation of state derived from it which is independent of the nature of the substance. Two substances are said to be in corresponding states when the reduced pressures, volumes, and temperatures have the same values; their properties are then similar. The ratio $RTc/PcVc=8/3$, being constant for all gases obeying van der Waals' equation, substances may be grouped according to the values given by their critical coefficient ratios. In the case of helium, whose molecules approximate the ideal structure imagined by van der Waals, the critical coefficient is 2·68, which is very close agreement with the theoretical value. While strictly speaking, it is not proper to apply the method of corresponding states to mixtures, yet it may be justified in the case of air, since its components are not very unlike. The critical region of any mixture, however, should be avoided. Previous work on the critical phenomena of air has shown that the temperature and pressure of the plait-point are — 140·78° and 37·25 atmos. respectively, and that this point is situated very nearly on the straight line joining the critical points of pure oxygen and nitrogen. Also, the density 0·36 at the plait-point is almost what the centre-of-mass law would give. Further, the critical point of contact, or highest temperature and corresponding pressure at which liquid is possible, is very near the plait-point, so that the data here may be taken for calculation of the critical efficient. The value thus obtained is 3·46 and lies between 3·42 for ethylene and 3·59 for carbon dioxide. In consequence a comparison of the isotherms of air and these two gases is made. Amagat has shown that if scales proportioned according to the critical pressures and volumes are used, the isotherms of different substances fall into the same family. Consequently when the proper scale has been determined, the critical data of a gas may be estimated from those of any other substance. Raveau improved on Amagat's method by plotting the isotherms in terms of log P and log V instead of P and V. This method has now been found to give the values of critical temperature and pressure with a higher degree of accuracy than that of most previous work. The air isotherms in terms of log PV/T and log P were drawn on a large scale on heavy paper. The isotherms of the other substances were drawn to the same scale on thin transparent paper and placed on the air curves. Then, by shifting the carbon dioxide or ethylene curves on the air curves they were brought into corresponding states. The mean of a number of trials gave the critical temperature of air, — 140·2 and 141·0 respectively, and the critical pressure 37·8 and 40·7 atmos. respectively. A diagram is given in the paper of the air and carbon dioxide isotherms. Except in the critical region the results are very satisfactory. H. H. Ho.

SOUND.

769. *Propagation of Sound and Fog-signal Efficiency.* **L. V. King.** (Roy. Soc., Phil. Trans. 218. pp. 211–293, April 23, 1919. Roy. Soc. Canada, Trans. 12. pp. 109–113, Dec. 1918, and March, 1919.)—This is a very full account of an elaborate investigation, the practical tests having had the advantages of co-operation with government departments as to privileges, equipment, and personnel.

The tests demonstrated the successful use of the Webster phonometer as a simple and practical instrument for the measurement of the characteristics of pure-toned sound-waves of ordinary intensity. By carrying out acoustic surveys with this instrument, the propagation of fog-signal waves under varying conditions of wind and weather has been studied. The observations show that the wind is by far the most important factor affecting sound propagation. Many of these results may be interpreted in terms of Taylor's theory of extinction of sound by the eddy structure of the atmosphere. From this point of view it may be expected that further work with the Webster phonometer will contribute materially to our knowledge of atmospheric structure.

By examining the distribution of sound along circular arcs at different distances from the source it is concluded that the greater part of the atmospheric losses occur within half a mile, and very probably within a few hundred feet of the siren trumpet. To measure the very intense sound-waves at this close range a less sensitive phonometer without a resonator is recommended for future work.

The paper includes appendices on the Webster phonometer, on acoustic surveys near Father Point, Quebec, and on the thermodynamic measurement of acoustic efficiency. It has also a large number of tables of observations and charts marked with the results obtained both along radii from the source and along circles with the source as centre. [See Abs. 655 (1917).] E. H. B.

770. *T. Wrightson's Theory of Hearing.* **W. B. Morton.** (Phys. Soc., Proc. 31. pp. 101–109; Disc., 109–110, April, 1919.)—This theory seeks to explain the power possessed by the ear of analysing into its component tones a compound aerial disturbance. It assumes (1) that impulses act on the mechanism of the ear corresponding to the maxima and minima of the compound vibration-curve, and also to the points where the curve crosses the axis; (2) that among the spacings of these impulse-points there is a preponderance of intervals which approximate to the periods of the component tones, their lower octaves and their combination tones, and that these spacings determine the sensations of the component tones. The present note is concerned with the second of these assumptions. Graphs are drawn which exhibit the way in which the distribution of impulse-points varies when the relative intensities and the phase-relation of the component notes are changed. Difficulties are found in (1) the large number of other spacings presented to the ear, (2) the variations of the spacings with loudness-ratio and phase relation, (3) the fact that in a single pure tone the spacing is one-quarter of the period of the vibration.

In the *discussion*, **W. M. Bayliss** protested against the notion that physiologists welcomed Wrightson's theory. It is the anatomist who says there is no structure in the ear capable of acting as a resonator, ignoring Helmholtz's demonstration that a membrane stretched unequally in different directions will resonate. Personally he saw no objection to the resonance theory. On T. Wrightson's theory there were four impulse-points per vibration. If the frequency of vibration is reduced far enough one ceases to hear a sound and hears only the separate vibrations. Why are the four impulses per vibration not noticed in this case? Another important point is one raised by Rayleigh. We can hear sounds up to 30,000 per sec. Now from what is known of nerve fibres, they are completely inactive for at least one-thousandth of a second after receiving an impulse, so they cannot possibly record more than a thousand separate impulses per sec. Thus, on Wrightson's theory, all sounds requiring more than a thousand impulse-points per sec. should sound alike. E. H. B.

771. *Analysis of Photographs of Fog-signals obtained by the Phonodeik.* **D. C. Miller.** (Roy. Soc. Canada, Trans. 12. pp. 161–169, Dec., 1918, and March, 1919.)—Describes a preliminary investigation of the loudness of fog-signals received at various positions and distances carried out by the author's phonodeik. [See Abs. 655 (1917).] E. H. B.

772. *The Halifax Explosion.* **H. L. Bronson.** (Roy. Soc. Canada, Trans. 12. pp. 31–35, June and Sept., 1918.)—A discussion of the explosion which wrecked Halifax on Dec. 6, 1917. The munition ship *Mont Blanc*, with 2500 tons of high explosives and a deckload of monochlorbenzene collided with the *Imo* near the Narrows of Halifax Harbour. E. H. B.

773. *Sound Fields and Sound Antennæ.* **W. Hahnemann** and **H. Hecht.** (Engineering, 107. pp. 224–226, Feb. 14, 1919.)—A translation in full of the second part of the author's original paper [see Abs. 1294 (1917)]. The first part has already been translated (*ibid.* 106. p. 756, Dec. 27, 1918).

774. *Acoustical Thermometer.* (Engineering, 107. p. 467, April 11, 1919.)—This apparatus, due to T. R. Watson and H. T. Booth, is a cylindrical resonance chamber with electrical coil to heat it and thermo-couple (of Pt and Pt-Rh) to determine its temperature, also a Rayleigh disc to detect when it is responding best. It is used to ascertain whether the speed of sound in air is strictly proportional to the square root of its absolute temperature. It is found to be so up to 400° C. Higher temperatures are to be tried with a modified apparatus. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

775. *The Linear Differential Equation for Coupled Electric Vibrations and the Roots of the Biquadratic.* **J. Sommer.** (Ann. d. Physik, 58. 4. pp. 375–392, March 14, 1919.)—This paper is largely occupied in discussing (for certain relations among the constants) the nature and algebraic sign of the roots of the auxiliary biquadratic which occurs in the solution of the differential equation for coupled vibrations. The differential equation itself is then solved and discussed for a variety of cases, the results being illustrated by a number of graphs. E. H. B.

776. *Relativity Law of Electrical Action.* **M. N. Saha.** (Phil. Mag. 37. pp. 347–371, April, 1919.)—After a brief recapitulation and discussion of the various empirical formulæ proposed for representing the interaction of two moving point-charges, the author sets out from the relativity standpoint to evaluate the potential four-vector a at an external point due to the motion of a point-charge, and finds it to be determined by the equation $a = ew/\mathrm{R}$, where e is the total charge, w the velocity four-vector of the electron, and R the four-dimensional perpendicular distance of the external point from the axis of motion of the electron. Since a is a four-vector of which the space components are equivalent to the vector potentials of electrodynamics, and the time component is $\sqrt{-1}\phi$, where ϕ is the ordinary scalar potential, this amounts to the translation of Liénard and Wiechert's result into a relativistic form. By applying this result to Lorentz's equations for the ponderomotive force on the electron, he obtains a Lagrangian function expressing the motion of two electrons around one another. He finds, moreover, that for small velocities the result is practically identical with the law of electrodynamic action tentatively assumed by Clausius in 1880. G. W. DE T.

777. *Calculation of the Charge carried by the Ions in Crystals.* **J. Wimmer.** (Phys. Zeits. 20. pp. 92–93, Feb. 15, 1919.)—Employing ultra-red radiation, Born [Abs. 972 (1918)] has determined the number of electrons in a molecular group of a crystal. Debye and Scherrer [Abs. 128 (1919)] have made a similar determination, employing X-radiation. The author now outlines a method of determining the ratio of the number of atoms v in the molecule to the number of positive charges z. In the case of diatomic crystals (NaCl, KCl, etc.), the author has shown [see Abs. 186 (1919)] that $v/z = (\mathrm{G}_1 + \mathrm{G}_2)/\sqrt{(\mathrm{G}_1 \,.\, \mathrm{G}_2)}$, where G_1 and G_2 are the atomic weights of the two component substances of the crystal. A table is given showing these values for ten different crystals. The tabulated values make it possible to determine "k" in Drude's dispersion formula $k = 0{\cdot}297 \times 10^8 p \,.\, z^2/\mathrm{G}_1\mathrm{G}_2$. The observed and calculated values of this constant show fairly good agreement. A. B. W.

778. *Electrical Theorems in Connection with Parallel Cylindrical Conductors.* (Phys. Soc., Proc. 31. pp. 111–130; Disc., 130, April 15, 1919.)—Many problems in connection with parallel cylindrical conductors occur in practical electrical work. The formulæ for the capacity between the conductors and for the effective inductance are well known, but the values of the capacity and potential coefficients and of the inductance coefficients have not yet been determined. It is shown that for the case of a cylinder inside a cylindrical tube their values can in all cases be easily computed. When the cylinders are external to one another, it is proved that the three capacity coefficients are connected by two very simple relations. Limiting values between which these coefficients must lie are found, and methods of obtaining closely approximate values in special cases are given. Whatever the charges on the cylinders may be, provided that the other conductors of the system are remote, the mutual force between them can be calculated to high accuracy when their distance apart is great or when the radius of one is small compared with that of the other.

Practically identical formulæ enable us to find the current-density and the inductance coefficients with high-frequency currents, both for a cylinder inside a cylindrical tube and for two parallel cylinders. In the latter case it is shown that when the phase-difference between the currents is less than 90 deg. the mechanical force between the cylinders is repulsive when they are close together and attractive when they are far apart. At a definite distance apart, therefore, the cylinders when carrying high-frequency currents are in stable equilibrium. Since the potential coefficients can always be determined experimentally, it follows that for high-frequency currents the inductance coefficients, which are equal to the potential coefficients, are also found by the same experiments. AUTHOR.

779. *Theory of Dielectric Hysteresis.* **U. Meyer.** (Deutsch. Phys. Gesell., Verh. 19. pp. 139–154, Aug. 30, 1917. Comm. from the German Telegraphs Experiment Station.)—A discussion of the different forms of the mathematical treatment of dielectric hysteresis. Pellat's attempt to represent the effect by introducing a term $K(1 - \epsilon^{-t/T})$ where K and T are constants, and t is the time elapsing since a change in the strength of the electric field, was improved by Schweidler [Abs. 650 (1908)] who introduced a series of such terms. The large number of constants thus involved was reduced by Wagner [Abs. 514 (1914)] by the supposition that the time-constants T were grouped around a most probable value T_0 according to some law of distribution. Tank [Abs. 814 (1916)] by measurements of the current at a very small interval after the application of the field, attempted to establish agreement between the hysteresis with direct and with alternating fields. Maxwell's representation of the dielectric as comprising two layers having different dielectric constants and conductivities, leads to the same formulæ as Pellat's, but with the advantage that the constants have some physical meaning. But Maxwell's representation needs to be amplified on the lines of Wagner's suggestion, and the importance of the different time-constants depends upon their relation to the frequency of the field. By assuming three layers, one of which the author shows must have dielectric properties very similar to those of water, Maxwell's theory thus amplified represents the facts closely in many cases. W. H. G.

780. *Dielectric Hysteresis and A.C. Losses.* **F. Tank.** (Deutsch. Phys. Gesell., Verh. 20. pp. 3–8, Feb. 28, 1918.)—A note on the work of Meyer [see preceding Abs.]. Tank refers to the difficulty in observing the current *immediately* after the time-value zero; a certain small interval always remains unobserved. He points out how by a graphical representation we may judge whether this unobserved portion may be safely extrapolated.

The action in many materials may be represented approximately by $\phi(t) = \beta . t^{-n}$ where β and n are constants and $0 < n < 1$. This gives good agreement with experimental results, both d.c. and a.c., over a very wide range. W. H. G.

DISCHARGE AND OSCILLATIONS.

781. *Ionisation Potential for Electrons in Helium.* **F. Horton** and **[Miss] A. C. Davies.** (Roy. Soc., Proc. 95. pp. 408–429, April 1, 1919.)—A continuation of previous work [Abs. 626 (1919)]. In view of the remarkable agreement of many of the deductions from Bohr's theory with experimental results, it was thought worth while to make another direct determination of the ionisation potential of helium, using a method by which a photo-electric effect of radiation could be distinguished from ionisation. The results of the experiments described show that radiation occurs when electrons having a velocity of about 20·5 volts collide with helium atoms, and that this is not accompanied by any ionisation of the gas. Ionisation occurs when the velocity of the electrons is raised to about 25·7 volts, and no other type of radiation is produced at this point. Accurate determinations of these critical potentials were made by making detailed investigations of the positions of the bends in the current–p.d. curves, by observations at intervals of 0·1 volt over a range of 2 or 3 volts, in the neighbourhood of the values already found. These experiments confirm Bohr's suggestion that radiation and not ionisation occurs at about 20 volts, but the value found for the ionisation potential is considerably lower than the value (29 volts) deduced from Bohr's theory of the structure of the helium atom. This discrepancy cannot be accounted for on the supposition that the low result obtained was due to high-speed photo-electrons coming from the filament, for the minimum ionisation potential was deduced by assuming that the critical point was due to the collisions of the swiftest electrons which could be detected coming from the filament, and the greatest velocity of emission which was observed was practically the same for accelerating potentials above and below the radiation potential. A. W.

782. *Ionisation and Radiation.* **R. A. Houstoun.** (Nature, 103. p. 145, April 24, 1919.)—When X-rays pass through a gas, only a very few molecules (in favourable cases, one in a billion) are ionised by them, and the extent of this ionisation is unaffected by temperature. Some have found difficulty in reconciling this with the wave theory of light. It is here suggested that the difficulty arises from an imperfect view of what the wave theory requires. The uniform spherical wave spreading alone from a point source is a mathematical fiction. What we really have is a large number of spherical wavelets, each diverging from a different electron, criss-crossing in various directions, and therefore interfering with one another. It follows simply from the laws of chance that the intensity must be exceptionally great at some points. If one in a billion molecules is ionised, the ionising intensity works out at twenty-eight times the average intensity at the place. Thus it is not necessary to assume that X-rays consist of neutral atoms, or that the ether has a fibrous structure, or to take refuge in the nebulous phraseology of the quantum theory. E. H. B.

783. *Determination of the Emission-Velocities of Electrons.* **A. Becker.** (Ann. d. Physik, 58. 5. pp. 393–473, April 4, 1919.)—A mathematical paper, divided into the following sections:—*Section I.*—Theoretical. *A. The laws* *of motion of electrons* in (i) Homogeneous field, (ii) Central field. *B. The distribution of electrons,* (i) External velocities—(*a*) *uniform* velocity: (*α*) emission the same in all directions, (*β*) emission according to the cosine law; (*b*) *non-uniform* velocity (general case); (*c*) Maxwell's distribution of linear velocities; (*d*) Maxwell's distribution of the "Volt"-velocities. (ii) Energy of emission and internal velocities—(*a*) internal and external spacial distribution: (*α*) emission the same in all directions, (*β*) emission according to the cosine law. (*b*) Distribution in the central field: (*α*) internal emission the same in all directions, (*β*) emission according to the cosine law. (*c*) Distribution curves in homogeneous fields: (*α*) internal emission the same in all directions, (*β*) emission according to cosine law.

Section II. Practical deductions.

Section III. Special applications:—*A.* The photoelectric effect. *B.* The electron emission from X-rays. *C.* The electron emission from canal rays.

A. B. W.

784. *Electric Discharge on the Surface of a Solid Electrolyte.* **Šulejkin.** (Phys. Rev. 13. pp. 197–208, March, 1919. Paper read at the Moscow Inst. of Science, May, 1918.)—In the electrolysis of some solutions an Al anode is rapidly covered with a coating of oxides after closing the circuit and the current falls almost to zero. The voltage may then be increased up to the "critical tension," but directly it is increased beyond this the current rises sharply and suddenly. Observation shows that, up to the critical tension, the layer is continually being broken through, new ruptures being formed while old ones close up. The equilibrium is therefore kinetic, not static. Above the critical tension, whenever at any point the insulating layer is broken through, the oxides adjacent to the rupture begin to take part in the discharge and there is immediately a characteristic vivid flash of white light. Photomicrographs of this discharge are given. The path of the discharge changes from $\overset{-}{\text{fluid}}\text{-}\overset{+}{\text{metal}}$ to $\overset{-}{\text{fluid}}\text{-}\overset{+\ \ -}{\text{oxide}}\text{-}\overset{+}{\text{metal}}$. In each case the discharge fluid-metal and oxide-metal takes place in a thin film of gas (oxygen). In the latter case the discharge is in the form of an electric arc, and the edges of the oxides (kathode of arc) are heated to white heat and rapidly destroyed. A Pt-wire anode does not show any changes in character of discharge on passing through the critical tension, but the characteristic discharge may be produced by the contact, in the solution, of a so-called solid electrolyte with the metal anode.

The critical tension (P) at which the discharge begins, depends on the concentration (*m*) of the solution, and on the composition of the anion but not on the degree of dissociation. For all the solutions used the formula $P = a/m^b$ holds. The dependence of the constants, *a* and *b*, on the character of the anion is given, and the formula $P = a/m^{1/2}$ derived theoretically making suitable assumptions.

T. H.

785. *A Theoretical Explanation of Canal Rays.* **G. Huch.** (Ann. d. Physik, 58. 3. pp. 201–290, Feb. 25, 1919.)—This paper is the continuation of a previous communication of 12 sections [see Abs. 73 (1919)]. Section XIII deals with radiation and energy of motion. Hitherto all comparisons have started from the ratio of the static and dynamic radiations; now the absolute values of these radiations are compared. This involves the measurement of the canal rays. Tables are included giving the data of Vegard's experiments. The results of the investigation of this section are as follows:—The amount of energy that is transformed by impact from kinetic into oscillatory, is directly proportional to the impact energy. In consequence the total radiation, which is equal to this transformed energy, is directly proportional to the kinetic energy of the canal rays. The energy transformation is of different magnitude for atoms and molecules, being greater for atoms, while it obeys, for every kind of particle, the law of proportionality with the impact energy, and, to the first order is independent of the nature of the other impacting particles. The factor of proportionality, which expresses the relationship between its transformed and impact energy is termed the impact capacity, and may be placed equal to the oscillation capacity. By increasing the electric tension (the potential difference), the energy transformations decrease and the total radiation thereby diminishes, since the molecules in the canal rays become more numerous and the sum of the impact capacities declines, with the consequent generation of less oscillation energy. If the pressure be increased, the sum of the transformations increases since it is proportional to the number of impacts; the total radiation therefore increases. Pressure-increase also shortens the free path, while the moving particles have a higher oscillation temperature due to impact; more energy, therefore, passes over to the static radiator, whose oscillation energy and radiation become in consequence stronger. The dependence of the transformation on the oscillation temperature has not been established with certainty.

Section XIV of the paper deals with radiation and charge. Wien's work is quoted as having afforded a means of understanding the charge relationships of the canal rays. After an exhaustive examination of this problem, the conclusions drawn are :—That the charge of the radiator exerts no detectable influence upon the light-effect, *i.e.* that charged and uncharged particles, for the lines investigated, are carriers and excitors of light to an equal degree. The relationships between charge and gas pressure, and between charge and discharge voltage are explained by the assumption that electrification is produced by molecular impact, and neutralisation by union with free electrons. At great dilutions the results of the experiments depend on the distance between the place of observation and the kathode, because the equilibrium of the processes in the canal beam is attained when the beam has passed through a definite layer of gas.

Section XV examines the Doppler-effect in oxygen, nitrogen, and mercury. Numerous tables of results are given and the following conclusions drawn :—With oxygen and nitrogen the same laws hold good for light-production by impacting particles as in the case of hydrogen, although with the latter a larger amount of oscillation energy is radiated between two impacts, and the oscillation capacity of the molecule is not so very different from that of the atom. In the canal rays from oxygen, only radiators of equal oscillation capacity are present, which on the ground of magnetic analysis must be regarded as atoms. The canal rays of nitrogen probably contain molecules as well as atoms. Hydrogen possesses a much higher capacity for oscillation energy than oxygen and nitrogen, while mercury vapour has a much higher capacity than the other gases investigated. The question as to whether an oscillation compensation takes place between the particles of different gases, cannot as yet be decided from the experimental data to hand. As generators of those parts of the spectrum which have no Doppler-effect, the electrical and molecular recombination processes come into notice. It is extremely probable that the band spectra of oxygen and nitrogen have been caused by the reunion of two atoms (molecular recombination). In canal rays elastic and dispersion impacts appear alongside those evolving light; in elastic impacts, the impacting and impacted particles exchange their state of motion, and correspond to the impacts of the kinetic theory of gases. The impact effect is proportional to the energy of the impact or to the square of the velocity of the impacting particle.

A third communication is promised. H. H. Ho.

786. *Influence of Transverse Magnetic Fields on the Spark Potential* **E. Meyer.** (Ann. d. Physik, 58. 4. pp. 297–332, March 14, 1919.)—In the introduction a brief historical sketch of work along similar lines is given. The apparatus used for the present experiments is illustrated diagrammatically and described in detail, as is also the method employed in making the measurements. Control experiments carried out for the purpose of ascertaining the best method, and degree of accuracy of the results obtained, are described The results are shown in both tabular and graphical form. The curves for the magnetic field $H=0$ show the known characteristic course, a decrease of the spark potentials with decreasing pressure until a minimum is reached at the critical pressure, and a rapid rise of the spark potentials with any further decrease in pressure. The product of the critical pressure p_0 and spark-length l is constant for the minimum potential. Reasons are given why the obtained minimum potential, 327 volts, and the product $p_0l=5{\cdot}67$ are considered correct values. The rise in the spark potentials increases with the strength of the magnetic field as well as with the spark-length, and, above the critical pressure, diminishes with increasing pressure. The minimum potential is raised in the magnetic field. The spark potential with $H=0$ is independent of the cross-section, at least so long as the electric field is sufficiently homogeneous. In a magnetic field (1960 c.g.s.) the rise in the spark potential is very markedly dependent upon the cross-section of the spark-path, and it diminishes with increase in the cross-section. Further researches are in progress in which it is hoped to eliminate the influence of the cross-section. A. E. G.

787. *Relation of Potential Distribution to Hysteresis Effect in the Wehnelt Tube.* **R. A. Porter.** (Phys. Rev. 13. pp. 189–196, March, 1919.)—The previous work of the author [Abs. 1037 (1918)] has shown that for such tubes, in general, both static and dynamic (alternating current) characteristics denote a hysteresis effect, *i.e.*, larger currents for decreasing than for increasing voltages. In the present paper three stages in the discharge are identified—one non-luminous and two luminous forms. Potential distribution curves for one pressure (0·01 mm.) and kathode temperature (about 1290° C.) are given for each stage, together with voltage-current curves for the two stages of luminous discharge. The potential distribution curves lie in three groups corresponding to the three stages. With the pressure and kathode temperatures used the non-luminous discharge may exist for the voltage range 40–50 volts and another stage may begin at 48 volts, so that in the region of 49 volts any of the three stages may be obtained.

A hysteresis in the current values and in the potential distribution exists when the potential is varied cyclically and this is apparent for slow cycles as well as for those of higher frequency. T. H.

788. *Conductivity in Electrodeless Ring Discharge.* **A. Hartmann.** (Schweiz. Elektrot. Verein, Bull. 10. pp. 52–60, March, 1919.)—Describes experiments bearing on the work of Wachsmuth [Abs. 229 (1918)] and Winawer. It is shown that the max. conductivity with a pressure of about 0·5 mm., which was observed by Wachsmuth and Winawer with all the gases they dealt with, is brought about by a secondary discharge at the probes, and consequently it cannot be regarded as a characteristic effect of the ring discharge. With a special arrangement of the apparatus, by which only the static effect of the coil was effective, it was shown that this secondary discharge at the probes was excited by the coil, and could be eliminated by earthing the coil. When this was done the conductivity was found to be considerably less than with Wachsmuth's arrangement, and the conductivity varied with the pressure, qualitatively at any rate, in the way that would be anticipated from the theory of ionisation by collision. Further, it was found that the ionisation of a gas increases with increased frequency of the exciting oscillations, and also that it is the greater the higher the potential at the spark-gap. A. W.

789. *Lissajous Figures.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 21. pp. 65–67, Feb. 28, 1919.)—If the kathode rays in a Braun tube are subjected to a periodic magnetic or electric displacement in a vertical plane and at the same time undergo a periodic horizontal deflection, the spot of light describes a curve of the Lissajous type. From this figure it is not always possible to evaluate both effects, but if one of the periodic forces is a known function of the time, it is easy to find the time distribution of the other force at right angles. In the present paper a method is described whereby both functions can be obtained, provided a certain relation exists between them. The solution of the Lissajous figure is not possible if both variables are the same function of the time and have a given phase-difference, but if one is the differential of the other a solution can be obtained. A. W.

790. *Analogue of Sustained Oscillations.* **P. Janet.** (Comptes Rendus, 168. pp. 764–766, April 14, 1919.)—If one supplies, from a series generator, a motor with separate excitation turning in a vacuum, the motor starts in one direction, then stops and reverses, and so on. It is pointed out that the behaviour of such an arrangement is analogous to the phenomena of sustained oscillations obtained with the Duddell arc or with a 3-electrode valve. The series dynamo behaves as a negative resistance, and the motor as a condenser. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

791. *Measurement of Capacity.* **J. Scott-Taggart.** (Electrician, 82. pp. 466–467, April 18, 1919.)—The arrangement described makes use of the beats produced by two sets of superimposed continuous oscillations of slightly different frequencies. A vacuum-tube set, including a pair of telephones, is arranged to oscillate continuously at a frequency which may be altered by means of a variable condenser. A second circuit, which also oscillates continuously, is brought near to the first, and the frequency of this second circuit is determined by the capacity of the condenser to be tested. The first circuit is thus affected by both frequencies, and beats may be obtained. A simple substitution method, using a standard condenser, gives the capacity of the condenser in question, the variable condenser of the first circuit being adjusted to give no beats with the condenser under test in circuit, and then the standard variable inserted and again adjusted to give no beats. Various other uses of the arrangement are suggested. A. W.

792. *Piezo-Electricity and its Applications.* **J. J. Thomson.** (Engineering, 107. pp. 543–544, April 25, 1919. Lecture delivered at the Roy. Inst.)—After enumerating the electrical properties of certain crystals, notably tourmaline

and quartz, as affected by heat or by pressure, the lecturer referred to the work of Curie in opening up this subject. He then showed how the piezoelectric properties can be used to determine the pressures obtained in explosion chambers, *e.g.*, in a gun-barrel. The slab of crystal, inserted in a gun-barrel has a leaf of metal on each face. These surfaces are connected by wires with two parallel plates in a vacuum tube. A stream of electrons from a hot tungsten wire is propelled through a fine tube and passes between the parallel plates. If the plates are at different potential, as will happen when the surface of the crystal is pressed during an explosion, the stream is deflected, and the deflection is observed on a photographic plate. The whole explosion takes only 1/50,000 sec., but as the electrons move at 6000 miles/sec., the effects can be registered. An alternating magnetic field acts parallel with the electric field and by producing an alternating up-and-down movement of the electrons enables the deflection to be traced as an indicator diagram. Curves and one photo-reproduction are given.

P. E. S.

793. *The Dielectric Constant and the Molecular Dipole Theory.* **O. Klein.** (Nobel Inst., Meddel. 3. No. 4. (24) [48 pp. German] 1918.)—A resonance method is described for capacity measurements from which the dielectric constants of the substance in question can be found. It was found experimentally that solutions of various alcohols in benzol and in chloroform (the solutions having the same molecular normality) have the same value for the dielectric constant. The same result was obtained with acetone and methylethylketone in benzol. Thomson's rule, that similar substances give the same value for $(\epsilon - 1)Mv$, was tested with mixtures of water with various alcohols, and with such mixtures was found to hold good. Some measurements by Pohrt of the dielectric constants of gases were found to show temperature coefficients to be expected on the dipole theory. Debye's formula $[(\epsilon - 1)/(\epsilon + 2)]v = A/T + B$ was altered to $(\epsilon - 1)(v - b) = A/T$, in which latter formula, for substances belonging to the same group, the constant A has a value such that $AM = L$. The constant L is proportional to the square of the molecular moment. In order to test the formula, the constant L was calculated in various independent ways for alcohol and acetone. For ethyl-alcohol in benzol and in the pure state the value found for L was 67,400. For gaseous ethyl alcohol $L = 65{,}900$, and from the temperature coefficient of the dielectric constant of water $L = 67{,}000$. Gaseous acetone gave the value $L = 180{,}000$, and for acetone in benzol and in the fluid state $L = 179{,}000$. The equation $(\epsilon - 1)(v - b) = A/T$ was tested by measurements of the dielectric constant of water at various temperatures, and very good agreement was obtained up to the highest temperatures used. The formula $K = L/T = M(v - b)(\epsilon_0 - 1) + \mu/[1 + k(\epsilon_0 - 1)]$ was found to hold for infinitely dilute solutions, and gives, together with the relation $(\epsilon - 1)(v - b) = A/T$, a means of determining the values of the constants K and b. From this the following approximate formula is derived: $K = \mu/[1 + k(\epsilon_0 - 1)]$; this allows K to be determined from measurements of the dielectric constants of solutions of the substance in question. The formula was applied to Walden's measurements of the dielectric constants of various salt solutions. A. W.

794. *A Small Motor using Thermionic Tubes instead of Sliding Contacts.* **W. H. Eccles** and **F. W. Jordan.** (Phys. Soc., Proc. 31. pp. 151–153, April 15, 1919. Electrician, 82. pp. 670–671, June 13, 1919.)—In this motor the rotating part is an ebonite disc with iron teeth on its periphery, and the stationary part comprises two electromagnets with their poles close to two teeth. One electromagnet is connected to the grid of a thermionic relay, the other is included in the plate circuit. When during rotation a tooth passing the grid magnet induces a voltage in its winding the consequent transient increase of current through the other magnet causes this magnet to exert a pull on the tooth approaching it. We thus have a small motor without commutator or spark which may under no-load be driven up to a speed of 4000 to 6000 revs. per min. from the lighting supply. AUTHORS.

795. *Lecture Apparatus for Demonstrating Ferromagnetic Phenomena.* **W. Kopp.** (Arch. des Sciences, 1. (Ser. 5) pp. 133–135, March–April, 1919.)—The principle employed is similar to that made use of in Ewing's hysteresigraph, but the two sets of indications, horizontal and vertical, are obtained by means of two string galvanometers. The instrument can be of much lower sensitivity than that possessed by most of such galvanometers, and some particulars are given of an easily constructed simple form which is capable of giving the large range of deflection necessary. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

796. *Vector Diagrams of some Oscillating Circuits used with Thermionic Tubes.* **W. H. Eccles.** (Phys. Soc., Proc. 31. pp. 137–149; Disc., 149–150, April, 1919.)—The method of the crank or vector diagrams used commonly in the study of a.c. circuits is here applied to the assemblage made up of an oscillator, the thermionic relay maintaining it in oscillation, and the devices linking these two parts. The diagrams then serve as substitutes for the usual treatment of the problem by differential equations and from them may be obtained all the formulæ. They have, besides, the advantage of exhibiting to the eye the phases of the currents and voltages in every part of the circuits. In forming the diagrams the potential drop across the oscillator is calculated by the usual rules of the a.c. diagram, and added geometrically to the potential drop across the tube. This total is made equal, in magnitude and phase, to the voltage applied at the instant to the grid multiplied by the voltage factor of the relay. In its turn the voltage applied to the relay depends upon and is obtained from the current running in a portion of the oscillator. The fitting together of these lines gives all the conditions to be satisfied for the maintenance of steady oscillations. AUTHOR.

RADIOGRAPHY AND ELECTRO-PHYSIOLOGY.

797. *New Guilleminot Fluorometer.* **J. Massiot.** (Archives d'Él. Médicale, 27. pp. 114–117, April, 1919.)—The principle of this apparatus is as follows. A surface of standardised luminescent paper surrounds a small square screen of platinocyanide of barium, as in ordinary photometric appliances. The platinocyanide is exposed to the X-rays; the luminescent standard is protected against these rays by lead. Intensity measurements are obtained by moving the tube from the X-rays until there is equality of luminescence of the two half-moons, and in determining the distance at which this takes place. The apparatus required for this purpose is described in detail, and illustrations of it are given. The apparatus may be used in ordinary daylight, although it is advisable to screen off too bright light when making observations. A. E. G.

798. *Development of X-ray Localisation Methods.* **J. T. Case.** (Archives d'Él. Médicale, 27. pp. 5–24, Jan., 1919.)—Includes a lengthy bibliography.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

799. *Absorption of Helium by Charcoal.* **S. McLean.** (Roy. Soc. Canada, Trans. 12. pp. 79–81, June–Sept., 1918.)—In a series of experiments the volumes of helium absorbed by 30 gm. of charcoal (kind of charcoal not stated) at the temperature of liquid air were found to be 0·14, 0·10, 0·15, 0·14, 0·24, 0·29 and 0·11 $cm.^3$ respectively. T. S. P.

800. *Ammonia Synthesis at High Temperature.* III. **E. B. Maxted.** (Chem. Soc., J., Trans. 115. pp. 113–119, Feb., 1919.)—Having shown [*ibid.* 113. p. 386, 1918, and Soc. Chem. Ind., J. 37. p. 232 ; see also Abs. 715 (1918)] that the formation of ammonia in a rapidly cooled high-tension arc decreases with rising temperature, passes through a minimum, and then increases, and that the ammonia content in equilibrium with N and H was 1·7 % by volume, 1·5 % being recovered by suitable cooling, the author describes further experiments with arcs of larger size. The arc is produced in a large inverted flask between Pt spheres, 1 mm. diameter, at the ends of Pt-wires entering through the neck. The wires are supported by a silica tube, slotted at the top so as to form a slit, 4 mm. long, 1·5 mm wide, in which the electrodes rest. The gas mixture enters the neck from the side and is withdrawn through the silica tube, down into which the arc itself is drawn a little consequently. The gas flow varied from 0·5 to 7·5 litres/hour, and the concentration of the ammonia rose from 0·49 to 1·2 % (at 0·85 litre) and finally went down to 0·32. As the nitrogen and hydrogen used were free from oxygen, it is considered established that the formation of ammonia is not secondary, and that NO is not first formed. By passing the same gas repeatedly (up to 32 times) through the flask, the ammonia percentage was raised to 1·7 by two passages, and to 2·0 by more passages ; the figures varied and higher yields might be due to the cooling. These latter experiments are to support the view that oxygen has no part in the ammonia formation. Temperature measurements are not made. H. B.

801. *Effect of Cold-working and Rest on Resistance of Steel to Fatigue under Reversed Stress.* **H. F. Moore** and **W. J. Putnam.** (Am. Inst. Mining Eng., Bull. No. 146. pp. 391–404, Feb., 1919.)—The steel examined contained 0·20 % C. The resistance to reversed stresses was measured in the Upton-Lewis machine and in all cases the curve obtained by plotting log N against log S, where N is the number of reverses endured before fracture and S the fibre stress, which is less than the elastic limit, was a straight line. This is in agreement with the logarithmic form of Basquin's equation $S = K/N$, where K and q are constants depending on the variation of stress, method of loading, etc. The tests indicate that an increase in static strength due to cold-working does not necessarily result in increased resistance to repeated stress. Especially for low stresses and large numbers of reverses the cold-worked samples are often inferior to normal ones. Cold pressing as distinct from cold stretching would appear to result in a somewhat improved resistance to fatigue as a result of repeated stress. Periods of rest for twenty-four hours were allowed in some cases between the first and second and second and third portions of the test. No marked benefit from these short tests could be detected. Boiling or ageing the cold-stretched samples does not improve the fatigue qualities of the samples for this form of test. F. C. T.

802. *Formation of Troostite at Low Temperatures in Carbon Steel.* **Portevin** and **Garvin.** (Comptes Rendus, 168. pp. 731–733, April 7, 1919.)—In previous researches [Abs. 119 (1917)] the authors had noted the formation of troostite on quenching a carbon steel at temperatures about 600° C. By interrupting the quenching operation and removing the sample from the quenching liquid the formation was determined at much lower temperatures, characterised always by a distinct recalescence the amplitude of which was about 80° C. The troostitic structure was thus developed down to 360° C. directly from the solid solution of Fe_3C in γ iron, and not as on tempering a fully quenched steel, as a break-down product of martensite. For quenching velocities less than the critical, the recalescence occurs at relatively high temperatures and a troostitic or pearlitic structure is observed, whether the quenching is interrupted or not. Interruption of a full quenching at or below 350° C. produces little alteration in the hardness, which results in a very efficacious method for preventing cracking during hardening. This shows that hardening-cracks are produced at relatively low temperatures when the steel is in the martensitic state. In one case the temperature at which cracking occurred was determined as 70° C. Too short an immersion, however, may also result in the formation of cracks. F. C. T.

803. *Influence of Various Factors upon the Critical Quenching Velocity of Carbon Steels.* **Portevin.** (Comptes Rendus, 168. pp. 346–348, Feb. 17, 1919.)—It has already been shown both thermally and micrographically that for a given steel quenched under otherwise constant conditions, the temperature of the carbon change-point is, for velocities of cooling greater than a certain critical velocity, lowered from $Ar1$ to $Ar2$. A further study of this phenomenon has been made from the point of view (1) of the duration (τ) of the cooling in the temperature-range 700°–200° C. as a function of the diameter (d) of cylinders geometrically similar of which the height was three times the diameter, and (2) of the hardness after quenching as a function of the duration and of the diameter of the test piece. A steel containing 1·07 % C and 0·08 % Mn was used. According as the diam. of the cylinder is greater or less than 13·5 mm., the curve τ/d consists of two discontinuous straight lines, while at the same time the hardness undergoes a sudden change of 200 Brinell units. These changes occur at the point at which the Ar point is lowered and at which the structure passes from troostitic to martensitic. In other steels similar changes occur at other values of diam. or quenching velocity. The critical quenching velocity appears to be a minimum for the eutectoid steel (0·9 % C) and is also appreciably lowered by the presence of Mn in the steel. Thus this critical velocity is for a steel with 0·8 % C and 0·2 % Mn more than double that of a steel with 1·0 % C and 0·8 % Mn. The minimum temperature at which quenching can occur is a function of the velocity of cooling and is lowered as this becomes greater. The effect of pressure set up in large samples during quenching plays an important part. F. C. T.

804. *Microstructural Features of Flaky Steel.* **H. S. Rawdon.** (Am. Inst. Mining Eng., Bull. No. 146. pp. 183–201, Feb., 1919.)—The defects known as "snow flakes," "flakes," or scabs do not appear in plain carbon steels, but occur very widely in alloy steels, particularly those of the nickel and

chrome-nickel type. In fractures, this type of defect shows up as a white, silvery, coarsely crystalline area against a darker and finely-crystalline background and is particularly liable to be developed in hardened specimens. The flakes usually have a definite and symmetrical arrangement in the piece in which they occur. They are revealed by radiographs. Microscopic examination indicates that the flake has no depth but is simply a discontinuity in an otherwise normal material. The discontinuities are intercrystalline and the flakes closely follow the grain boundaries. They are associated with extremely thin films of true slag either continuous or formed of tiny, isolated globules. Flakes originate in the ingot, in which they appear like intercrystalline shrinkage cracks, and actually occur in the cast metal along with the slag inclusions in the angles between the branches of the tree—like dendrites. In the finished state they form discontinuities in the metal which have resulted from the working down of the slag inclusions. Though they are usually associated with dirty steel, the fact that steel is dirty is not a sure criterion for condemning the metal as defective because of flakes.

F. C. A. H. L.

805. *A Volute Ageing Break.* **H. M. Howe** and **E. C. Groesbeck.** (Am. Inst. Mining Eng., Bull. No. 146. pp. 181–182, Feb., 1919.)—The authors describe some spiral fractures occurring in hardened and tempered steel shrapnel helmets. The fractures developed spontaneously some weeks after the helmets had successfully passed the ballistic test. F. C. A. H. L.

806. *Prevention of Columnar Crystallisation by Rotation during Solidification.* **H. M. Howe** and **E. C. Groesbeck.** (Am. Inst. Mining Eng., Bull. No. 146. pp. 361–365, Feb., 1919.)—Quiescence during solidification favours the formation of columnar crystals normal to the cooling surface. During solidification there arises a "littoral" layer of liquid, bathing the solidified walls. This layer is more fusible than either the solid metal or the central liquid metal and solidification can only continue by diffusion or convection so as to bring the still liquid metal into contact with the walls. In this way quiescent freezing can only occur by columnar growth, and in the later stages this favours segregation of phosphorus. Agitation tends to keep the solidifying walls in contact with fresh liquid metal and thus diminishes the tendency to columnar growth. Experiments carried out on the solidification of various materials in still and rotating moulds showed that in every case coarser crystals were obtained during quiescent solidification than during solidification with agitation. F. C. A. H. L.

807. *Work Hardening of Lead, Tin, and Thallium.* **P. Nicolardot.** (Comptes Rendus, 168. pp. 558–560, March 17, 1919.)—Cylinders of these three metals (13 mm. high by 18 mm. diam.) were reduced to half their initial height by blows from a falling tup and, within 10 secs. of the deformation, ball hardness determinations were made. Further hardness determinations were made after varying intervals of time and also after annealing at 100° C. The results show that these three metals are hardened by deformation and that their annealing, in spite of its rapidity, is subject to the laws governing the annealing of other metals. Spontaneous annealing occurs at ordinary temperatures and the rate of recovery increases as the temperature is raised. Hardened lead and thallium show no signs of softening after 24 hours' immersion in solid carbon dioxide, but in the subjection of tin to this treatment complications ensue because of the partial occurrence of the allotropic change. F. C. A. H. L.

808. *Gases from Copper.* **H. M. Ryder.** (Frank. Inst., J. 187. pp. 508–509, April, 1919.)—Gives an account of the gases given off during the heating of annealed copper containing 0·05 % Cu_2O. The gas removed was collected, out of contact with the copper, for 12-hour periods, the temperature of the Cu being increased 50 deg. C. immediately after the removal of each sample. The max. amount of CO_2 was obtained at 350° C., and this is probably due to a property of the gas since this maximum is present in curves similarly obtained for steel, iron, glass, and porcelain. The release of a large quantity of oxygen is noted at 800° C. due to the decomposition of Cu_2O. The maximum in the hydrogen curve is at 600° C., due to the fact that Cu becomes permeable to hydrogen at this temperature. C. O. B.

809. *Precision Method for the Determination of Gases in Metals.* **H. M. Ryder.** (Am. Electrochem. Soc., Trans. 33. pp. 197–202; Disc., 202–204, 1918.)—The metal to be investigated is mounted as a thin ribbon or filament in a lamp bulb, which is then evacuated. The temperature of the filament is then raised by an electric current, and the pump being kept going the gases evolved are continually forced out into a collecting tube. The temperature is raised in steps of 50 deg. C. up to the melting-point, the gases evolved at each temperature being measured and analysed. The bulb is water-cooled, in order to prevent the glass giving off gases on becoming heated. One or two mm.^{3} of gas can be thus measured and analysed. Silicon steel was found to give off gas abundantly at the A*r*2 point (730° C.). The method of analysis of the gas is novel. AUTHOR.

810. *Crushing Strength of Magnesia-Silica Mixtures at High Temperatures.* **O. L. Kowalke** and **O. A. Hougen.** (Am. Electrochem. Soc., Trans. 33. p. 215–225; Disc., 225, 1918.)—Though magnesia melts only at 2800°, it becomes plastic and mechanically weak above 1600°. When up to 7·5 % silica is mixed with the magnesia, the material is stronger. The magnesia was of 99·92 %, the silica pure quartz; both the materials were finely ground, mixed with 10 % of water and compressed into cylinders which were baked and then tested in an electric furnace. On the cylinder is placed a disc of graphite, and pressure is applied through a carbon tube by means of a weighted lever, the tube serving as black body for the pyrometer (Holborn-Kurlbaum) observations. It was found that the rate of temperature-rise during the baking was of influence even below 1000°. In the final tests the temperature was raised, during baking, at the rate of 10 deg. per min., up to 2100°; but there was a loss of weight amounting to 10 % above 1900° and to 27 % at 2200°. Failure occurred, during the hot test, at 1680°, 1800°, 1860°, 1830° when the magnesia contained 0·3, 7·5, 12 % of silica. The failure occurred (at 1680°) under a load of 4·65 kg./cm.^{2}, whilst 7·5 % silica-mixture stood a temperature higher by 190°; the pure magnesia gave way gradually, the mixture with silica abruptly, however; above 2000° the carbon attacked the magnesia rapidly. Microscopically periclase (MgO) and forsterite (silicate) were identified, the latter being formed above 1500° and acting as binder. In the *discussion,* **L. E. Saunders** pointed out that, owing to the loss by evaporation at high temperatures, the strongest mixture need not contain the 7·5 % SiO_2 assumed. H. B.

811. *Liquid Crystals.* III. and IV. **W. J. H. Moll** and **L. S. Ornstein.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 254–258, and pp. 259–261, 1919.)—III. Melting and congelation phenomena with *p*-azoxyanisol. IV. A thermic effect of the magnetic field.—Owing to the fact that the particles of liquid-crystalline substances are directed by a magnetic field, the question whether perhaps the action of the field may entirely or partially manifest itself as heat, was investigated, a thermo-element of special form being used. An effect is indeed observed, but this is only apparent at the wall of the thermo-element and therefore probably has its origin in the elastic change of form of the liquid-crystalline particles. L. H. W.

812. *Conductivity of Dilute Alloys free from Mixed Crystals.* **H. C. Burger.** (Phys. Zeits. 20. pp. 73–75, Feb. 15, 1919.)—Recently Lichtenecker has published a notice [see Abs. 1272 (1918)] on the conductivity of alloys free from mixed crystals, in which he gives values for an alloy of any desired concentration. Previously he had calculated the conductivity for an alloy of equal parts by volume of both components, under the assumption that both metals were orientated in a cube in chess-board fashion. Lichtenecker opines that the result obtained affords a good approximation for the case where the boundaries of the zones of both metals are of any given shape. The object of the present paper is to show that the form of the boundary between the metals has a very important influence upon the conductivity. The calculation of the conductivity for any given concentration offers great difficulties, and, in consequence, investigation has been limited to the particular case where the concentration of one of the components has a very small value. Here the metal present in the smaller amount is distributed throughout the other in small isolated regions associated together in simple fashion. The argument is entirely mathematical, and the conclusion is drawn that the conductivity of such a dilute alloy not only depends on the concentration and on the specific conductivity of the components, but also is very essentially influenced by the form of the boundary between them. This is probably the case also for alloys of any given concentration. Without definite knowledge of this boundary it is impossible to calculate the conductivity. No great importance can therefore be attached to Lichtenecker's result for a 50 % alloy. H. H. Ho.

813. *Control of Hydrogen Manufacture by Schilling's Apparatus.* **F. Bourion and C. Courtois.** (Comptes Rendus, 168. pp. 232–235, Jan. 27, 1919.)—Shows the amount of error introduced into the measurement of purity of hydrogen with Schilling's apparatus, if the humidity of the gases is neglected, and proposes a correction for this, and a table giving at once the correction to be applied to the readings at any temperature.

J. W. T. W.

814. *Studies in Catalysis.* X. *Applicability of the Radiation Hypothesis to Heterogeneous Reactions.* **W. C. McC. Lewis.** (Chem. Soc. J., Trans. 115. pp. 182–193, March, 1919.)—The velocity constants of heterogeneous reactions have smaller temperature coefficients than those of reactions in homogeneous systems, and, on the basis of considerations previously developed by the author, can be interpreted as being due to the critical increment in heterogeneous reactions being less than in homogeneous reactions. As previously shown, the reactivity of a substance depends on the magnitude of its critical increment, which is taken into account by the exponential term, $\epsilon^{-E/RT}$, which appears in the velocity expression. E is the critical increment per gm.-molecule, and the greater its value the greater is the temperature coefficient. If a reaction occurs in a homogeneous system and

E_1 represents the sum of the critical increments of the reactants, whilst E_2 represents the sum in the presence of a catalyst, the ratio of the velocity constants with and without a catalyst is given by

$$e^{-E_2/RT}/e^{-E_1/RT} = e^{(E_1-E_2)/RT},$$

E_1 being greater than E_2. This ratio is, in general, a large positive quantity, and may be called the catalytic factor. Consider now a process which involves the dissociation of a gaseous molecule. If this occurs in the homogeneous phase the critical increment is large and of the order of 50,000–100,000 cals. per gm.-mol.; the energy has to be supplied by absorption of the radiation present in the system. If, however, a catalyst is present which is capable of condensing or adsorbing the gas in the atomic form [compare Langmuir, Abs. 171 (1917)], the energy required is essentially that of sublimation or de-sorption of the atomic resultants from the surface diminished by the energy of adsorption or condensation of the molecular reactant. Such effects are in general small, of the order 5000–10,000 cals. per gm.-mol. Hence in this case the catalytic factor would be $e^{(50{,}000-5000)/RT}$, which for $T = 1000°$ would correspond with $e^{22·5}$, or 10^{10} approximately. It is evident that the effect considered is of very great magnitude, and to this extent is in agreement with the known high efficiency of heterogeneous catalysts. From the point of view of the energy changes involved, therefore, the action of a catalyst may be ascribed to the substitution of relatively small energy terms of the nature of de-sorption or sublimation effects in place of true critical energies of activation or dissociation. In general, the problem is not so simple as the case above considered, and in order to render clearer the possibilities which present themselves a preliminary examination of the following reactions is given: oxygen and sulphur; oxygen and hydrogen; oxygen and silicon. The details of these considerations can only be appreciated by reference to the original paper. T. S. P.

815. *Determination of the Molecular Complexity of Liquid Sulphur.* **A. M. Kellas.** (Chem. Soc., J., Trans. 113. pp. 903–922, Dec., 1918.)—The author has devised an apparatus by which the capillary rise of liquid sulphur can be measured between the melting-point and boiling-point. The sulphur must be freed from impurities, especially sulphuric acid, sulphur dioxide, and hydrogen sulphide, and this purification can be effected by distillation and subsequent boiling in dry nitrogen, the gases evolved being pumped off. In the case of mobile sulphur, S_λ, between the temperatures of 115° and 160°. At 119·4° and 156° the mean values for the surface tension are 60·46 and 56·38 dynes respectively, the corresponding molecular surface energies being 653·4 and 615·9 ergs. The corresponding value of K is 1·02, and the average multiplying factor for S_2 is 2·996. The molecular complexity of at least 95 % of mobile sulphur (S_λ) between 115° and 160° is presumably represented by the formula S_6, assuming the validity of the Ramsay and Shields method of calculation. The angle of contact of sulphur and glass was taken as zero. In the case of viscous sulphur, S_μ, it was found, in disagreement with the results obtained by others, that the surface tension of sulphur falls continuously from the melting-point to the boiling-point, being 48·2 dynes at 280° and 39·4 dynes at 445°. The molecular complexity alters about 160°, and it might be stated as a first approximation that an endothermic termolecular polymerisation appears to occur near that temperature. The aggregate, S_{18}, seems to be stable up to near the boiling-point. The polymerisation may be due to a tendency of sulphur to lower its valency with rise of temperature, the complex S_6 possessing a residual valency at 160°. Other methods of calculation of molecular complexity seem to emphasise the aggregate S_6, but the results do not seem to accord with experimental averages so well as those of the Ramsay and Shields method. Calculations of critical temperature give two variant values depending on the temperatures of calculation. Above 160° the value found is 1390°, corresponding with the complex S_{18}. Below 160° the inadmissible value of 766° is obtained, corresponding with S_6. A. F.

816. *Equilibria in the Reduction of Oxides by Carbon.* **R. E. Slade** and **G. I. Higson.** (Chem. Soc. J., Trans. 115. pp. 205–214, March 1919.)—The equilibria studied are of the type: metal + carbon $\rightleftharpoons$ carbon monoxide + metal, or metal oxide + metal carbide $\rightleftharpoons$ carbon monoxide + metal. There is only one degree of freedom, and therefore one pressure of carbon monoxide which determines the equilibrium of the system. It is shown that if the equilibrium pressure is as low as 50 mm. there is no complication due to the presence of CO_2 at temperatures from 850° upwards, and consequently care was taken to work at pressures less than 50 mm. The apparatus used has already been described by Slade [Abs. 687 (1913)]. With vanadium the reaction is probably $VO + VC = 2V + CO$, and the mean equilibrium pressure of CO at 1340° is 1·45 mm. By Nernst's heat theorem the heat of reaction is then calculated to be 80,875 cals., and the pressure of CO would be 1 atmo. at 1827°, *i.e.* at this temperature VO would be reduced by the carbide under a pressure of 1 atmo. Experiments with tantalum were not very satisfactory, but the equilibrium pressure of CO at 1270° was found to be 0·1 mm. With chromium the reaction is probably $5Cr + CO \rightleftharpoons Cr_4C + CrO$, and at 1339° and 1292° the equilibrium pressures of CO were 9·2 (6·2) and 4·4 mm. respectively. T. S. P.

817. *Experiments with the Copper Cyanide Plating Bath.* **F. C. Mathers.** (Am. Electrochem. Soc., Trans. 33. pp. 147–151; Disc., 152–154, 1918.)—In a copper cyanide plating bath, as usually worked, it is found that the current yields (ampere efficiencies) at the kathodes are generally lower than those at the anode, so that copper accumulates in the bath and it is necessary to make regular additions of sodium cyanide from time to time. Sodium carbonate and (possibly) sodium sulphate are valuable additions to the bath. In baths containing almost the minimum necessary amount of sodium cyanide, the addition of sodium hydroxide lowers both the anode and kathode yields. The anode yields are high in both hot and cold solutions if a sufficient quantity of sodium cyanide is present, but the kathode yields are much lower in the cold than in the hot solution. A bath containing 6 oz. copper cyanide, 5·7–6·3 oz. sodium cyanide and 5·8 oz. sodium carbonate per gallon and operated at 60°–80° C. is recommended; it gives practically 100 % efficiency at both electrodes. It is more concentrated than the baths generally used, but can be operated at a higher current density (6–9 amps. per sq. ft.) and the deposits are much better than usual. In the *discussion*, the author's recommendations are adversely criticised. T. S. P.

818. *Electrolytic Refining of Tin.* **E. F. Kern.** (Am. Electrochem. Soc., Trans. 33. pp. 155–166; Disc., 167–168, 1918.)—An account is given of laboratory experiments in which the anodes were of crude tin, cast into thin plates 4 in. long, 1¾ in. wide, and ⅜ in. thick, whilst the kathodes were made of sheet tin, 1/64 in. thick and larger than the anodes by a quarter of an inch on each of the two edges and bottom. The anodes contained 96 % Sn, the impurities being 0·5 % Fe, 0·1 % As, 0·2 % Sb, 2 % Pb, 0·6 % Cu, 0·1 % Bi, and 0·5 % Ag. The current densities used were either 12 or 24 amps. per sq. ft. at the kathode. The results obtained show that addition agents are necessary for the electro-deposition of dense, adherent deposits of tin. Stannous fluosilicate is the best electrolyte, and the presence of free hydrofluosilicic and hydrofluoric acids is beneficial, in fact, 60 % of the total acid content may consist of HF without being detrimental. The best deposits were formed in a stannous fluosilicate electrolyte containing 5 gm. of tin as $SnSiF_6$ and 7·5 gm. of free H_2SiF_6 per 100 cm.^{3} when aloin was present in amounts corresponding with 1 gm. aloin per 500 cm.^{3} of electrolyte. Peptone also gave good results as an addition agent. Good deposits were also obtained in the presence of peptone with the following electrolytes: sodium stannous chloride, ammonium stannous chloride, and stannous chloride. Only in the case of the stannous fluosilicate electrolyte did the addition of gelatine, quinoline, oil of cloves, or boric acid improve the deposition of tin.

T. S. P.

819. *Production of a Direct Current by Application of an Alternating E.M.F. to a Voltameter with Platinum Electrodes.* **P. Vaillant.** (Comptes Rendus, 168. pp. 687–689, March 31, 1919.)—When an alternating e.m.f. is applied to two Pt electrodes of unequal size (370 mm.^{2} and 1 mm.^{2} respectively) immersed in dilute sulphuric acid, direct current is produced in the sense that the small electrode becomes positive with respect to the larger one. The e.m.f. increases continuously with increase in the value of the alternating current, until electrolysis takes place. For example, in the following table, I represents the value of the alternating current in milliamps., e_1 the polarisation in millivolts of the small electrode, and e_2 the polarisation of the large electrode.

I.	e_1.	e_2.	
12	− 13·7	− 13·0	
20	− 5·5	− 13·0	
40	+ 19·3	− 9·2	
60	+ 30·4	+ 1·3	
120	+ 232	+ 179	(gas evolved at the small electrode).

T. S. P.

820. *Polarisation with Alternating Current.* **P. Vaillant.** (Comptes Rendus, 168. pp. 768–770, April 14, 1919.)—The phenomena described in a previous paper [see preceding Abs.] are shown to be general, platinum being replaceable by Zn, Fe, Al, Cu, Pb, or brass. The e.m.f., which is taken as positive when the small electrode is positive, changes, as the applied alternating current is increased, from negative to positive for Cu and Al, from positive to negative for Fe, remains increasingly negative for Pb, becomes decreasingly negative for brass, and remains positive and practically constant for Zn. The electrolyte used was a solution of NaCl, and the e.m.f. was never greater than a few millivolts. The polarisation produced is not connected with the fact that the electrodes are of different size, since the same phenomenon occurs when mercury electrodes of equal area are used. It is explained by the assumption that under the action of the alternating current layers of ions, which are alternately positive and negative, accumulate on the electrodes; the recombination of these ions is not immediate, in the sense that after the application of current has ceased, if

depolarisation is sufficiently rapid these layers are eliminated by diffusion before recombination is complete. Polarisation is then set up because the capacities of the electrode are not the same for the two ions. Using a Pt electrode of the Wollaston type, and of area 1·2 mm., against an indifferent electrode, the author has determined its capacity under different conditions in electrolytes of H_2SO_4, NaCl and $NaNO_3$. As long as electrolysis does not take place the capacity remains practically constant, the alternating polarisation increasing proportionately to the intensity of the current. As soon as electrolysis takes place the polarisation capacity increases rapidly and proportionately to the current, but the e.m.f. of polarisation remains constant.
T. S. P.

821. *Effect of Iron Sulphate in the Electrolytic Precipitation of Copper from Sulphate Solution with Insoluble Lead Anodes.* **E. F. Kern.** (Am. Electrochem. Soc., Trans. 33. pp. 131–141; Disc., 142–146, 1918.)—Solutions of copper sulphate (2·5 gm. Cu and 6 gm. free H_2SO_4 per 100 cm.) containing varying quantities of ferrous sulphate (0, 0·75, 1·50 and 3 gm. per 100 $cm.^3$ of electrolyte) were electrolysed with insoluble lead anodes at 20° or 50° C. and with varying current densities (5–30 amps. per sq. ft. at anode and 5–20 amps. per sq. ft. at kathode), in order to determine the effect of the iron salt on the current efficiency of copper deposition at the kathode. There is a considerable decrease in efficiency in the presence of the Fe, and this was found to be due to oxidation of ferrous to ferric salt at the anode, and reduction of ferric to ferrous salt at the kathode. Smoother and purer copper is deposited at 50° than at lower temperatures, but in the presence of Fe the current efficiency is lowered by heating the electrolyte. In the absence of Fe the current efficiency remains very high even though the copper in solution is reduced to as low as 0·2 gm. per 100 $cm.^3$. Higher current efficiencies are obtained with kathodic current densities of 10–20 amps. per sq. ft., than with 5 amps. per sq. ft. In the presence of Fe the copper deposit is less smooth and dense and the voltage necessary for electrolysis is less than when Fe is absent.
T. S. P.

822. *Electrolytic Behaviour of Manganese in Sulphate Solutions.* **G. D. van Arsdale** and **C. G. Maier.** (Am. Electrochem. Soc., Trans. 33. pp. 109–124; Disc., 124–129, 1918.)—Manganese may be deposited at the kathode, from neutral sulphate solutions, with 80–90 % current efficiency and at voltages from 3 volts upwards. Acid is formed at the anode, and with increase of acidity the efficiency is lowered, until with 0·36 % free H_2SO_4 there is practically no deposition of Mn. The deposit is powdery and could not be improved in any way. At the anode, however, Mn may be deposited as MnO_2 with nearly 100 % efficiency; acid decreases the efficiency in cold solutions, but at 65°–75° C. there is very much less effect. From warm acid solutions (up to 15–20 % H_2SO_4) containing more than 5 % $MnSO_4$, MnO_2 may be deposited in the form of a dense, black, lustrous film, using current densities up to 25 amps. per sq. ft.; the current efficiency is high. Impurities which are reducing agents cause a decrease in current efficiency in proportion to the amount present. For the deposition of elementary manganese, either Fe, Cu, or Pt kathodes were used, with graphite anode. When MnO_2 was deposited, graphite or Pt anodes were used.
T. S. P.